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DESIGN
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INDUSTRIAL
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37: Journal Section, American Society of Heating and Ventilating Engineers

JANUARY
1943
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***GENSPRING** Constant-Support Hangers are custom-made from standard parts . . . pre-fitted to each installation!*

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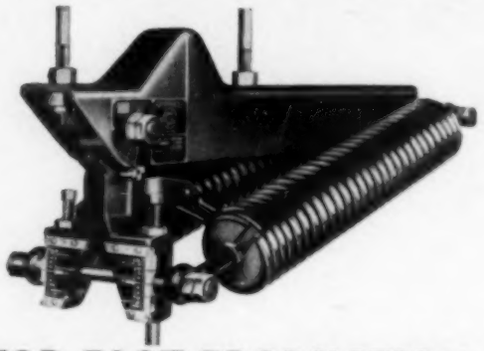
Through exclusive patented design, GENSPRING Hangers provide *constant support* for power piping in all "hot" and "cold" positions. The full safety factor of the supported system is always maintained.



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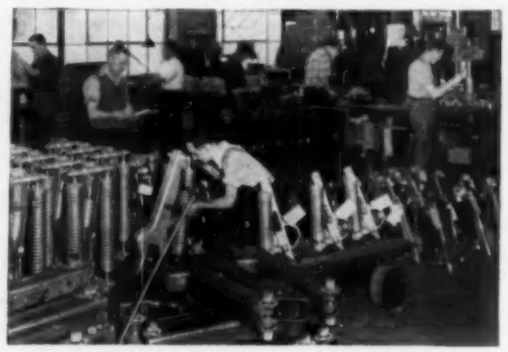

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Each GENSPRING Constant-Support Hanger is *pre-tested and calibrated* under conditions that duplicate its actual-service requirement. There's no need for load adjustment on the job . . . no chance of misfit hanger installations.

GENSPRING **CONSTANT-SUPPORT HANGERS BY**

GRINNELL

WHENEVER PIPING IS INVOLVED

THE EDITOR'S PAGES

N. R. BERNZ NEW CONTRIBUTING EDITOR

A new name appears this month on HPAC's board of consulting & contributing editors—N. R. Bernz, author of several articles on how to make dust counts published during 1942.

Mr. Bernz arrived in the United States from Sweden in 1921 on a temporary visa for professional studies, liked this country so well that he became a citizen.

During the following 10 years he was associated with leading consulting engineers and contractors specializing in heating, ventilating, and air conditioning, following which he established his own consulting practice. In 1934 he became interested in the technical phase of occupational disease prevention among industrial workers, i.e., control of the atmospheric environment in industrial plants. In addition to his other interests, he was active in this specialized field for a period of some eight years, directing the industrial hygiene work for a group of casualty underwriters. He recently resigned from this position to join the Luria Steel & Trading Corp.

OIL RATIONING PLAN DOESN'T GUARANTEE 65 F

It is unfortunate that there is the impression that the fuel oil provided under rationing will allow temperatures "of about 65." In reality, the consumer, in deciding whether to try rationed oil or convert, should thoroughly understand that the words "maximum temperature of 65 F" describe the basic plan. Even then, in order to secure 65 F, he must have added such fuel saving devices as storm sash, weatherstripping, and insulation *since last year*, because, as the rationing plans are working out, nearly all users are being given two-thirds of last year's oil, adjusted for weather only. There is, generally speaking, a 30 F differential between our average outdoor and indoor temperatures in this climate. Obviously, therefore, the most that a user can hope for with two-thirds of his former oil is two-thirds of 30 F or 20 F, thus raising his temperature from 40 to 60 and not to 65. Of course, if last year he kept his rooms at 80, or otherwise wasted oil, he might be very comfortable with two-thirds, but this is just one of the factors pointing toward a serious national problem as the weather becomes colder.—ALLEN J. JOHNSON, Anthracite Industries, Inc., in a paper presented at the annual meeting of the ASME.

WPB ANNOUNCES AIR CONDITIONING GROUP

The division of industry advisory committees of WPB has announced the formation of a general refrigeration and air conditioning committee.

The government presiding officer is Sterling F. Smith, of the general industrial equipment division. Members include Donald French, vice-president, Carrier Corp.; C. V. Hill, Jr., vice-president, C. V. Hill & Co., Inc.; J. B. Rainbault, manager, air conditioning and commercial refrigeration dept., General Electric Co.; F. S. McNeal, president, Universal Cooler Corp.; M. G. Munce, assistant to president, York Ice Machinery Corp.; Harry Newcomb, vice-president, Servel, Inc.; W. D. Jordan, vice-president, Liquid Carbonic Corp.; R. O. White, manager, cooler div., Day & Night Mfg. Co.; A. B. Schellenberg, president, Alco Valve Co.; and E. R. Walker, Fedders Mfg. Co.

Why We Must Have Scrap

1) To provide for current needs, and to build a stockpile from which our steel mills may draw to fulfill the production schedules set up by the War Production Board.

2) Because scrap metal has previously been refined, most of the impurities have been removed. Hence, mixed with pig iron, it makes steel faster than if made from 100 per cent pig iron.

3) Even in normal times steel mills used 50 per cent scrap. Now, with demands increasing daily for finished steel, the percentage of scrap needed is even higher, since use of substantial proportions of scrap actually speeds production.

4) Half of every tank, gun, submarine and ship is made from iron and steel scrap.

HENDERSON LEAVES ACRMA FOR NAVY

Charles E. Wilson, president of the Air Conditioning and Refrigerating Machinery Association, announced last month that temporary leave of absence had been given William B. Henderson, executive vice-president of ACRMA. Mr. Henderson has been ordered to duty as a lieutenant in the United States Naval Reserve. In World War I, Mr. Henderson served as a pilot with the Royal Air Force.

Miss Mary Jane Stewart, who has collaborated with him in association operation for the past 10 years, will serve as ACRMA executive officer in his absence.

WELDING AWARD PROGRAM FOR STUDENTS

The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, sponsor of the 1937-38 and 1940-42 $200,000 arc welding award programs, announced last month its first award program in the field of undergraduate engineering study.

The foundation's new project is the $6750 annual engineering undergraduate award and scholarship program. Its object is "to encourage engineering students to study arc welded construction so that their imagination, ability and vision may be given opportunity to extend knowledge of this method and thus aid the war effort and the economic reconstruction in the peace which is to follow."

LIST OF U. S. WAR FILMS

It is not generally realized that the Bureau of Motion Pictures of the Office of War Information, Washington, D. C., has sponsored a comprehensive series of informational movies, industrial training films, civilian defense training films, and films of the armed forces. The OWI has a listing of these films which includes the names and addresses of the distributors.

HPAC readers responsible for planning programs for engineering meetings or gatherings of other groups will want to have a copy of this list.

THE EDITOR'S PAGES

Continued

EMERGENCY STANDARDS FOR FITTINGS AND INSULATION

Through action of its committee E-10 on standards, the American Society for Testing Materials has recently issued 32 new standard specifications and test methods. Of these, 13 are emergency specifications and tests designed to expedite procurement or conservation of critical or strategic materials. All of these new specifications are being printed in separate pamphlet form (the emergency specifications on pink stock) and copies can be obtained at 25 cents each from ASTM headquarters, 260 S. Broad St., Philadelphia.

Emergency specification ES-20 covers malleable iron flanges, pipe fittings, and valve parts, including parts to be assembled, manufactured in advance, and supplied from stock by the manufacturer or distributor. This standard resulted from the prompt work of committee A-7, which acted on a suggestion from the WPB conservation division that standardized requirements for these fittings would aid the substitution of malleable iron for copper in some valve parts, also substitution of iron valves for brass valves 2 in. or smaller. This shifting of material has been urged to conserve copper.

Twelve of the emergency specifications, as developed by committee C-16 on thermal insulating materials, cover various types of thermal insulating material in different forms and for service at widely varying temperatures, ranging from surface temperatures of 200 to 1900 F.

GAS AND OIL FIRED WATER HEATERS LIMITED

Gas fired and oil burning water heaters were added last month to the list of products which will be manufactured next year only for use in war housing or other war projects by limitation orders restricting production and limiting the amounts of metal and metal alloys that may be obtained by the industry in 1943.

Production of metal tank jackets and metal tank supports is suspended and the installation of metal tank jackets is prohibited with certain minor exceptions.

Civilian needs for replacements of gas fired water heaters in 1943 and thereafter must come out of existing stocks. Necessary replacements may still be made for some time in the future, however, since inventories of finished equipment are comparatively large at present, according to the government.

Two new limitation orders were issued. L-185 deals with gas fired and oil fired water heaters, while L-199 prohibits manufacture and installation of metal tank supports and provides a simplification schedule to govern the manufacture of black iron and galvanized iron range boilers and expansion tanks.

COAL HEATING STOVE ORDER IS ISSUED

A unique rationing program, which aims to encourage rather than restrict buying, has been planned by the fuel rationing division of the Office of Price Administration to facilitate the selective distribution of coal heating stoves. A large quantity of fuel oil will be conserved for essential war purposes through the substitution of these coal heating stoves for heaters which are oil fired, says the OPA.

The weight and quantity restrictions on coal heaters under WPB order L-23-c have been lifted until January 31, 1943, and the manufacturers' iron and steel quotas have been increased 50 per cent for the months of February and March 1943.

Several thousand of the magazine type Army No. 1 heater, already manufactured for Army account have been released for civilian use. The War Production Board has also released additional stockpiled of materials for the Army No. 1 heater, as well as several months' productive capacity in the plants working under Army heater contracts.

The emergency heating stove rationing program is formalized in ration order No. 9, effective December 18, 1942. Under its provisions, the retail sale of both new coal fired heating stoves and new oil fired heating stoves, except to the Army, Navy, Marine Corps and Maritime Commission, will be restricted to those consumers who have been granted a certificate of purchase by their local war price and rationing boards. This order, which is effective throughout the area in which fuel oil is now rationed, applies only to new heating units and does not affect the sale of cooking appliances.

ALBERT KAHN IS DEAD

With the passing of Albert Kahn on December 8, the world lost a man who has long been recognized as one of the outstanding industrial architects of our industrial age. At the time of his death, Mr. Kahn was in the midst of the greatest program he had ever undertaken—that of making America the arsenal of democracy by building war plants bigger, better, and faster than such plants had ever been built before.

Two years ago the incorporation of Mr. Kahn's firm was changed and it assumed the name of Albert Kahn Associated Architects and Engineers, with 25 key men as associate members—among whom are G. S. Whittaker, mechanical engineer specializing in heating, and Herbert E. Ziel, mechanical engineer specializing in ventilating and air conditioning.

Louis Kahn, formerly assistant administrator of the firm, now steps into his brother's place as chief administrator.

WHAT IS DORMANT SCRAP?

Obsolete machinery, tools, equipment, dies, jigs, fixtures, etc., which are incapable of current or immediate future use in the war production effort because they are broken, worn out, irreparable, dismantled, or in need of unavailable parts necessary to practical reemployment.

FOLLOW THIS RULE

If it hasn't been used for three months, and if someone can't prove that it's going to be used in the next three—sell it—or scrap it!

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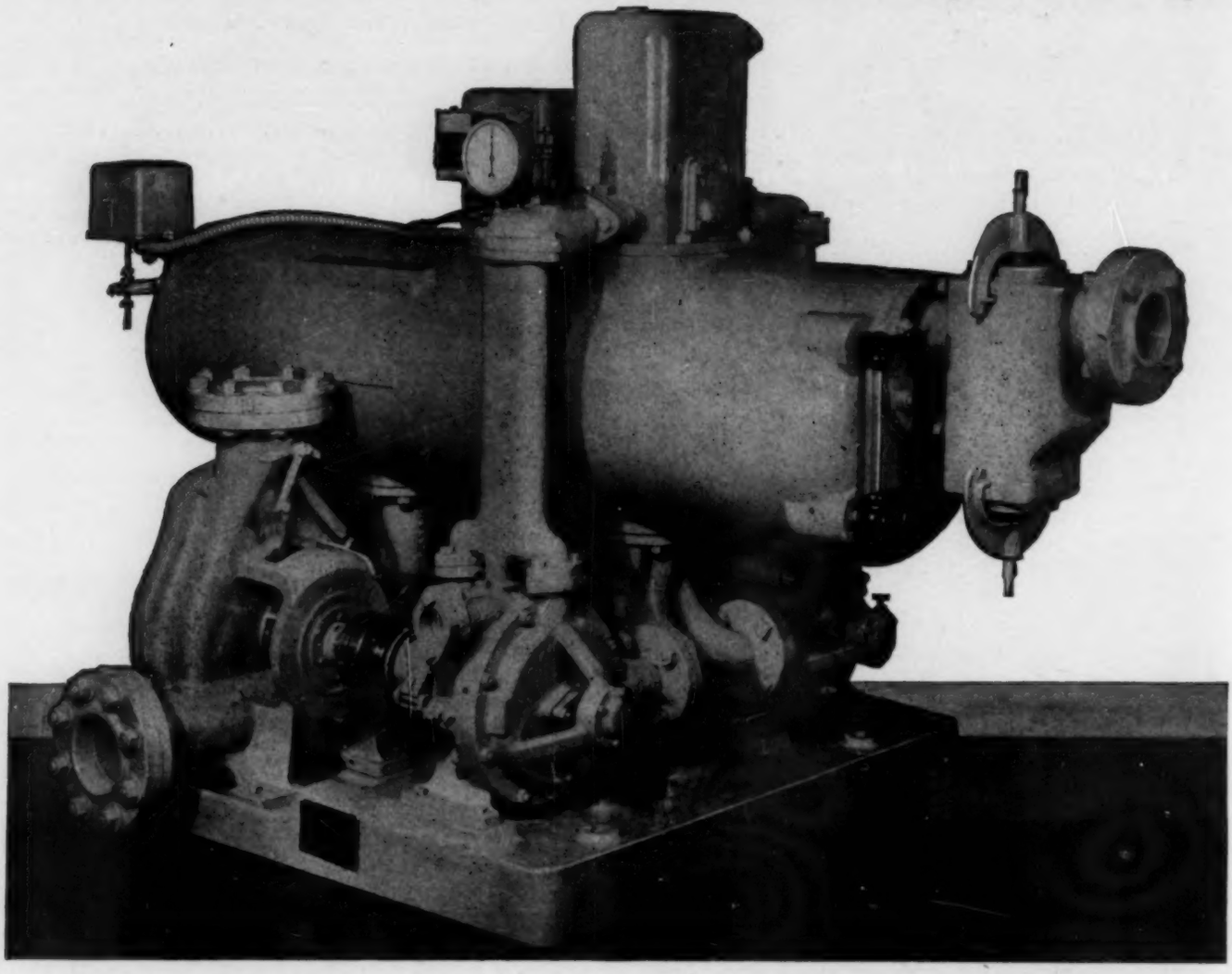
Where Heat Must Not Fail— Install this SAFE Heating Pump!



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is entirely independent of electric current failure, and continues to operate as long as there is steam in the system.

More than that, the Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump.

Greater savings still are effected by the Vapor Turbine in the system, for the reason that this pump operates continuously. It is the only pump that can do this with economy. Continuous operation means uniform circulation, and uniform circulation saves steam.

The Nash Vapor Turbine has but one moving part, rotating in the casing without metallic contact, and requiring no internal lubrication. Quiet, compact, and trouble-proof. Bulletin A-290 is free on request.

THE NASH ENGINEERING COMPANY

SOUTH NORWALK, CONNECTICUT, U. S. A.

The steam distribution line, looking toward the customer's property. Covers protect spring supporting hangers

Central Station Supplies Steam to Industrial Plant for War Use

Piping Arrangements for Steam Supply and Metering Described

SUMMARY—Interchange of power and steam between utility central stations and industrial plants—and utilization by utilities of waste fuel from industrials—has resulted in mutual benefits to both parties in many cases. Piping engineers are naturally vitally concerned with the subject, as the main pipe line must be carefully designed and be of the correct size for the estimated flows. Special consideration must also be given to numerous piping details, particularly the method of metering the steam consumption. . . . The author of this article, who must remain anonymous, is an engineer with the utility company that is a party to the contract described. His article covers the arrangements for supplying steam to an adjacent industrial plant engaged in war production, with data on the steam metering under various flow conditions and the determination of the steam billing rate

THE PROPOSITION of situating industrial plants adjacent to central stations from which power and steam can be supplied or waste fuel can be utilized has always been a subject of interest to power and piping engineers. A number of piping problems naturally are involved. Where such interconnections have been made, the arrangement has provided many mutual benefits to both parties. When steam and power are supplied, the manufacturing concern has not had to install, operate, and maintain equipment foreign to the manufacture of its product. The utility in most cases can use reserve capacity, thereby increasing the use factor of installed equipment. Where waste fuel is available from the industrial concern, there is an added incentive for such interchange.

Most of the older generating plants are not situated near industries requiring steam and there are not suitable sites near them for new industries with which interconnections can be made. Where new generating plants are being erected, however, there is an increasing number of such interconnections. Among the most recent are those between two oil refineries and adjacent electric power plants where power, steam, and fuel are interchanged.

Engineering Studies of Interconnection

On several occasions during the past 15 years, the author's company has made extensive engineering studies for established industrial customers to determine whether or not it would be economical for them to purchase steam in large quantities for heating and process work, or to establish whether they should buy power and dispose of waste fuel to our generating stations. In two instances, power-fuel interchange agreements have been made. Only recently, however, has an interconnection for the supply of industrial steam been made.

Other proposed steam interconnections had not been made for various reasons—either the indus-

trial plant's boiler installations were enlarged, the demand for more steam did not materialize, the cost of supplying steam was excessive because of the cost of long steam lines involved, or the steam cost seemed excessive.

Engineering studies on one interconnection were started several years ago to determine the feasibility of supplying steam to a war production plant to be erected on a site adjacent to the generating station. A number of different equipment arrangements involving supply from evaporators and different steam quantities were investigated. A definite contract was signed and the special facilities were recently installed.

Evaporator to Supply Customer

The equipment erected in the generating plant is somewhat complicated because no condensate is returned to replace the steam sent out. The existing evaporators in the station for supplying plant makeup have only small excess capacity, insufficient to replace the loss of distilled water had the customer's steam been taken from the plant steam system. In order that this condition would not interfere with the regular plant cycle or introduce complications in the treatment of the boiler feedwater supply, a single large evaporator was installed to supply the customer.

Space is available in the plant for a second evaporator when the steam demand exceeds the present capacity. The distribution main from the plant to the customer's property was designed and installed to handle the ultimate steam demand. (See flow diagram.)

Deaerating Water Softener

Raw water from the plant service water header is fed into a conventional hot process, lime soda, deaerating type water softener from which the evaporator supply pump feeds the evaporator through a float operated control valve. Steam at 375 psi ga and 720 F is taken from the station steam system for the evaporator coil supply. This inlet steam is controlled by a pressure operated valve actuated from the pressure of the steam leaving the evaporator, normally 175 psi ga.

Plant saturated steam was not used because, with light plant loads and only a few boilers in service at low evaporation rates, the diversion of saturated steam might result in excessive superheater tube temperatures.

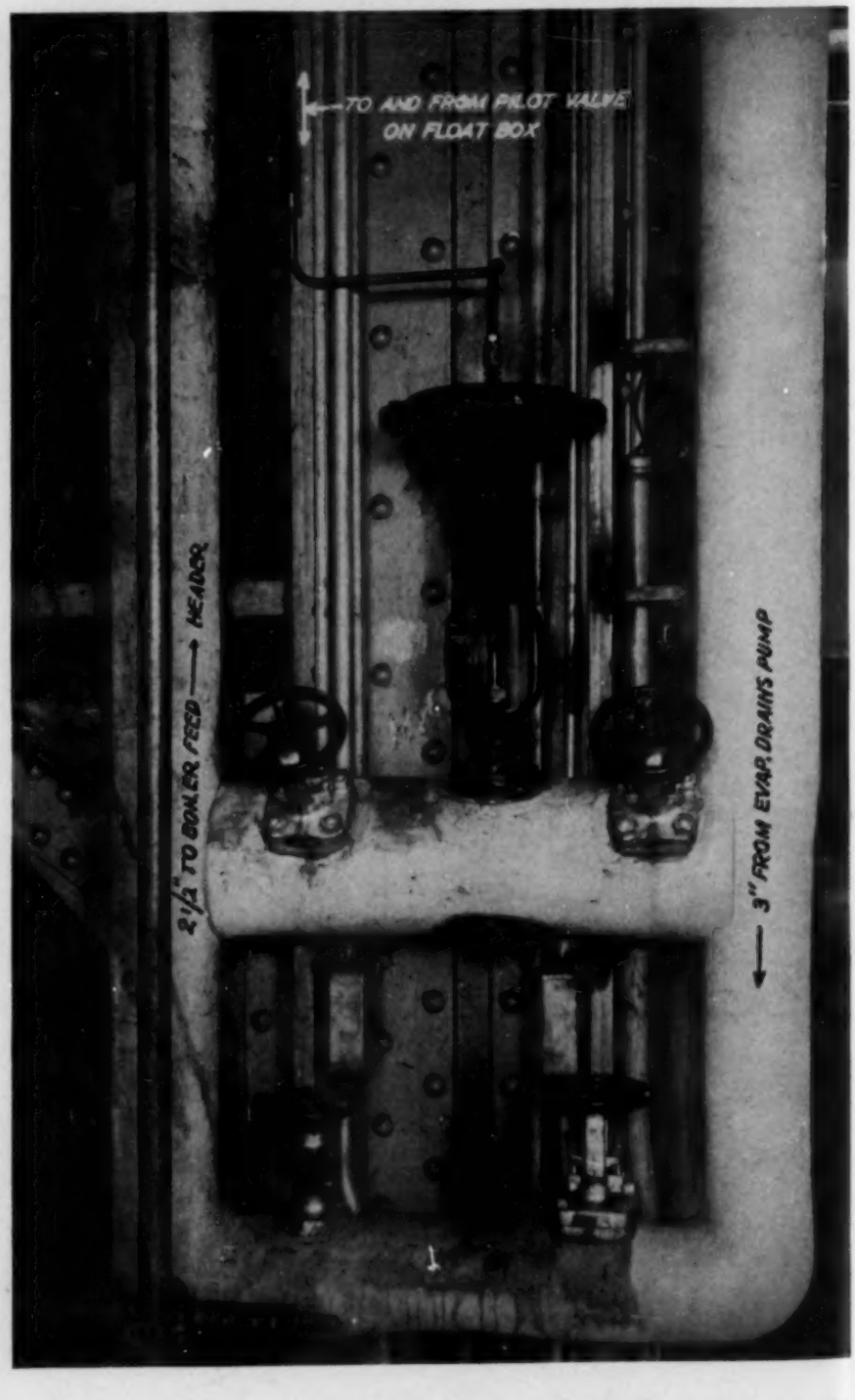
Hand Controlled Desuperheater

On the recommendation of the manufacturer, after the evaporator had been placed in service, a hand controlled desuperheater was installed in the steam supply line to lower the steam temperature below 450 F. The manufacturer's recent experience had indicated that admiralty tubes would fail under the original operating conditions and that trouble could be expected with rolled joints at the tube sheets because of temperature gradients across the tube sheets.

Disposal of Evaporator Drains

The method of disposal of the evaporator drains was dictated by several factors—the desire to use a constant speed pump, requiring a minimum of operating attention;

Automatic throttling valve in discharge line of evaporator drain pump



the wide variation in flow of drains to be handled; and the varying pressure of the station boiler feed system into which the drainer pump discharged. The pump, as installed, handles 120 gpm of 440 F water against a net total head of 240 ft at 3510 rpm. It is similar to pumps which have given good service handling hot oil in refineries. To care for flows as low as 10 gpm, a drains receiver was installed in the pump suction and equipped with a float control which actuates a throttling valve in the pump discharge. For any flows, therefore, the throttling valve tends to maintain the system in equilibrium.

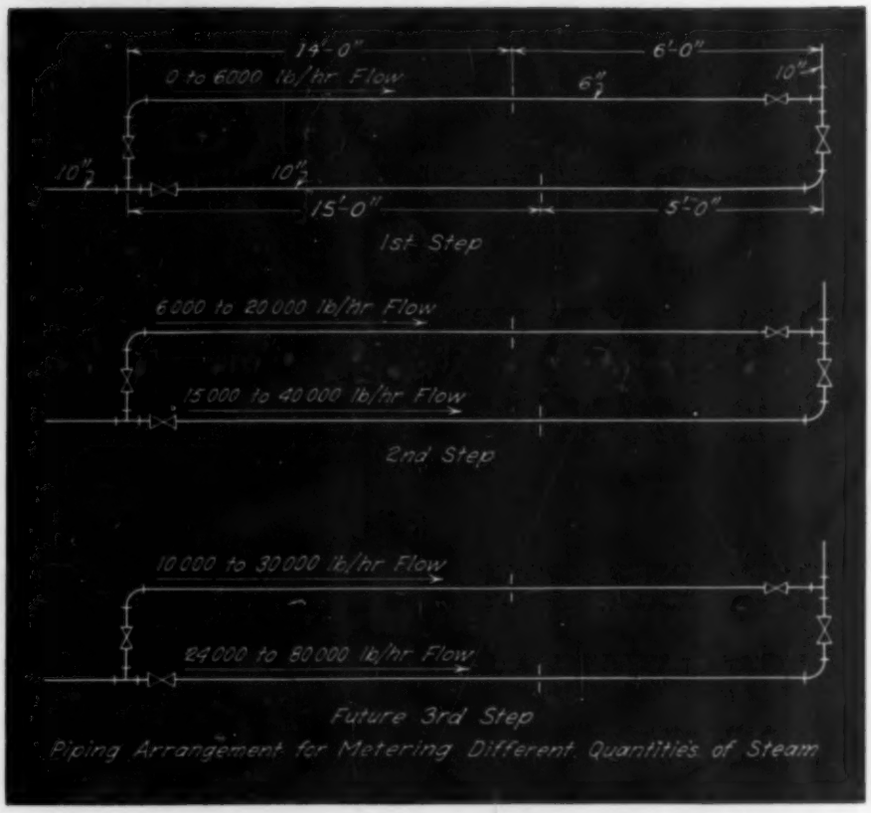
At small flows, a ¾ in. line connecting the pump discharge with the drains receiver is opened to insure a flow at all times through the pump in the event that the throttling valve should momentarily close. If the boiler feed header must be cut out, with the evaporator in service, drains up to about 20,000 lb per hr can be diverted to the station drip system through a second line at the pump discharge. This line also is used to drain the coils when scale is cracked because, with the low suction head available, the drainer pump will not pump into the boiler feed system.

Continuity of Supply When Evaporator Is Out of Service

Continuity of supply to the customer when the evaporator must be out of service for maintenance or cleaning is assured with a bypass arrangement. Station superheated steam can be bypassed through an automatic pressure-temperature reducing station through which the flow can be maintained during short shutdowns. During longer periods of outage, however, it may be necessary to restrict flow to as low as 4000 lb per hr to conserve the station supply of distilled condensate, used for plant makeup.

Why Water Softener Is Needed

The original layout of equipment did not include the water softener. The use of raw water in the evaporator would have given the customer steam containing up to 7 ppm of oxygen and from 60 to 80 ppm of carbon dioxide, both of which would be corrosive, especially when contained in the condensate. The deaerating softener as installed reduces the oxygen to less than 0.05 ppm and the carbon dioxide to 10 to 12 ppm, which should not cause corrosion in the customer's heat exchange equipment and piping. A sand-gravel filter, which would have reduced the total solids in the water leaving the softener from 150 to 125 ppm, was not installed. The saving in labor and maintenance entailed in its operation will, it is thought, more than offset the loss resulting from a slight increase in evaporator blowdown caused by the higher solid content of the feed.



Piping Arrangement for Metering Different Quantities of Steam

Ten Inch Steam Line

The 10 in. steam line is approximately 1350 ft long. The size was selected on the assumption that the ultimate flow will be of the order of 70,000 to 80,000 lb per hr. At this flow the pressure drop will not exceed 25 psi.

The pipe line leaves the station at sufficient height to provide crane and locomotive clearance. Use was made of the electrical mat steel adjacent to the station to support the overhead portion on the utility company property. The line is all welded construction and, due to the directional changes required in the layout, the necessary provisions for expansion were obtained without the use of any special pipe bends. The pipe is insulated with 2 in. of formed rock wool block and a coat of finishing cement. The covering was weatherproofed with an asphalt base emulsion trowelled over the covering.

Metering the Steam Flow

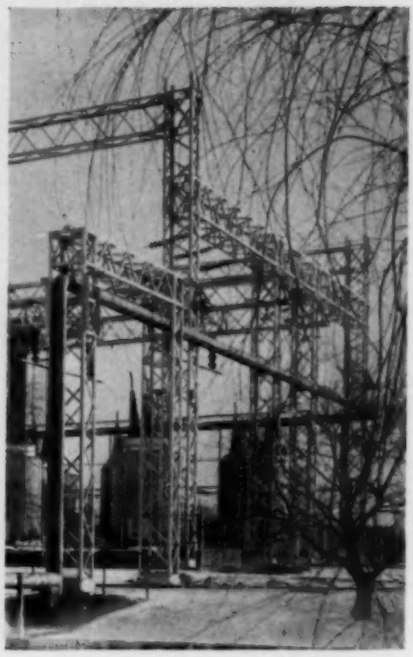
The metering of the steam flow was complicated by the wide variation in flow and the fact that the condensate could not all be collected at one place in the customer's plant and run through a conventional condensate meter. The arrangement adopted consists of two orifices, either of which can be operated with a standard mechanical flow meter secondary element. With this setup the flow can always be measured through an orifice in which the quantity falls within the 30 to 100 per cent range of the orifice. This provision will give an overall meter accuracy of ±2 per cent, not possible with a single primary element. The total 24 hr flow is obtained by integrating the chart with the constants corresponding to the orifices in use.

The piping containing the orifices was so designed that three metering conditions could be met. These steps are shown in the diagram. During the first step, a

small orifice was installed in the 6 in. line to meter building heating steam required by the customer. The 10 in. line was not in use. The second step shows the orifice capacities for the present one evaporator installation. When and if a second evaporator is installed, larger capacity orifices can be installed as shown in the third step of the diagram. This arrangement not only provides for accurate metering but will eliminate shutdowns of the entire system necessary for orifice plate inspection or replacements.

Rate at Which Steam Is Sold

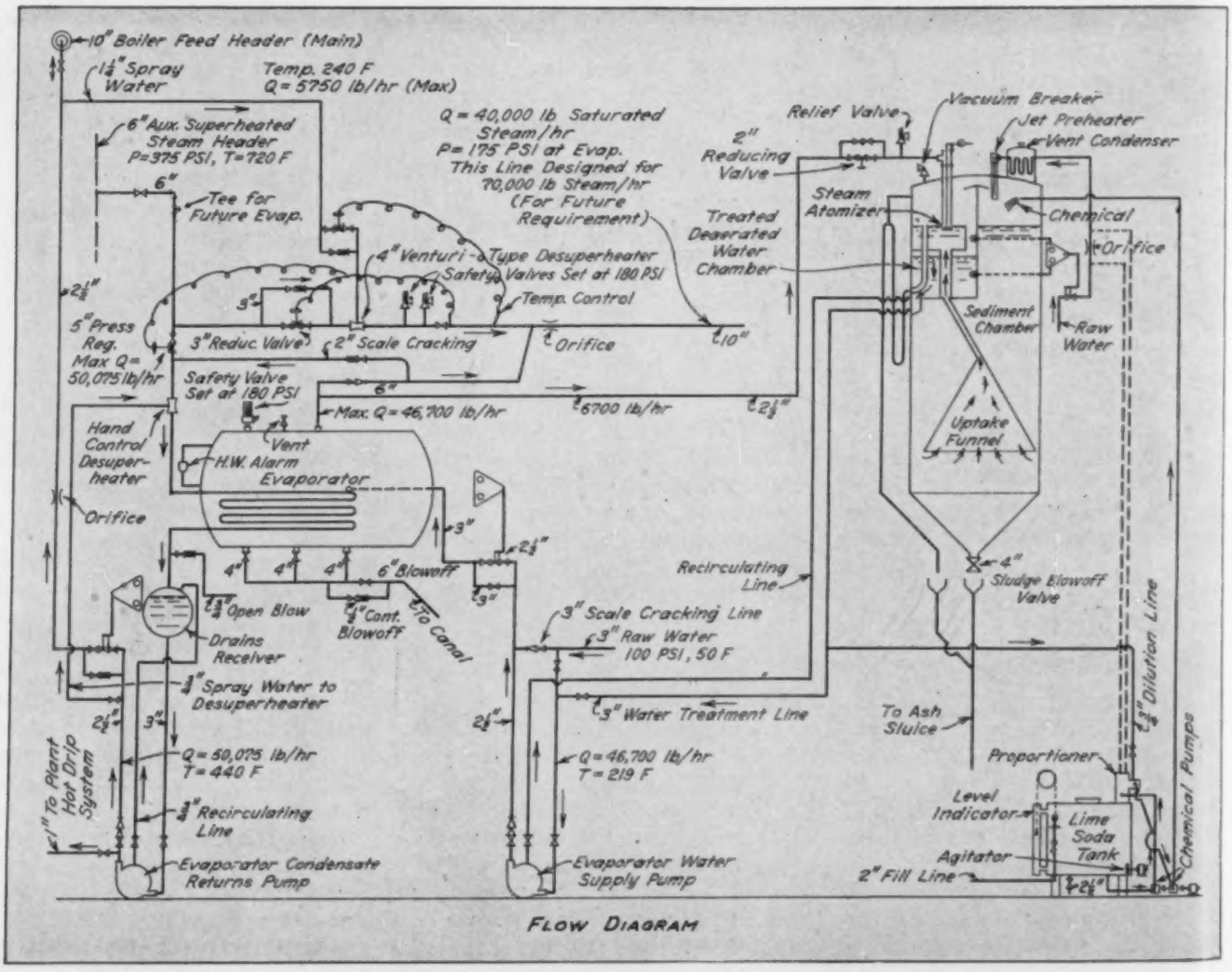
The rate under which the steam is sold consists of two parts. The agreement calls for a fixed monthly payment during the life of the contract by the customer to amortize the special facilities required to supply steam, plus a charge per 1000 lb of steam supplied equal to the cost to the utility company of 141 lb of coal. The cost of this coal, which is adjusted up or down at the end of each quarter of the calendar year, represents the cost to the utility company of the steam generation. It includes operating labor, maintenance, fixed charges on a proportional part of boiler house equipment required to supply steam to the evaporator, a contingency item, and fuel costs (which comprise the major portion of this item).



A view of the steam line showing the use made of the electrical mat steel for support

In the event it is necessary to change materially from present grades of coal, which average 13,200 Btu per lb, the rate will be adjusted by mutual agreement.

During the period in which steam has been supplied, no operating troubles have been experienced, although the steam demand has not been as great as expected. Operation under these conditions has enabled the operators to become familiar with the equipment and make necessary adjustments, which will reflect in better service to the customer when his steam demand is increased to the normal quantity expected.



FLOW DIAGRAM

A Consulting Engineer's Experiences in

WAR ENGINEERING

SUMMARY—Blackout plants for wartime production have introduced numerous problems in ventilation, air conditioning, and heating. High heat gains from motors, illumination, and processes—and oil haze where large quantities of coolants are used—are among the factors which have had to be considered; in one case, electrostatic air cleaner cells are used to remove oil from exhaust air, the oil being reclaimed for reuse. . . . Mr. Lewis, well-known consulting engineer and member of HPAC's board of consulting & contributing editors, tells us here of some of his war engineering experiences and includes numerous practical suggestions for solving some of the problems met with in our great war production factories. His article is taken from a talk made at a meeting of the Illinois chapter of the ASHVE.

I WISH that I were young enough to be carrying a gun or piloting a plane. I wish that I could be telling of hairbreadth escapes and of battles in which I participated. While I did come by a close shave under the age which allows me to carry a draft card, my experiences have all dealt with preparations for opposing air raids and with plants for the manufacture of war material.

I started in August, 1941, with the mechanical equipment of air raid warning stations. This work involved making a number of airplane trips, and a never-to-be-forgotten automobile trip with the Army.

Blackout Aircraft Plant

The next experience was with an air conditioned factory for aircraft accessories. The first building of two essentially duplicates is about 800 ft by 500 ft under one roof, with many interior divisions. The electric power load is so great that refrigeration to the extent of 5200 tons is needed. There was little experience by anyone else to draw on in this pioneering design—all of the experience was contemporary. There are two basic schools of thought in air conditioning these enormous blackout plants. One school uses central systems with large supply fans in apparatus rooms often on the roof and may employ direct expansion "Freon" refrigeration from multiple compressors. Another uses many air supply systems of smaller size, involving more fans and smaller motors, with a reduced amount of ductwork, and may employ centrifugal refrigeration and chilled circulating water.

We had heated several very large manufacturing plants before the

war, using many units and few ducts, and had pioneered to some extent with forced circulation hot water as the heat transmitter. We also had pioneered with refrigerated water for summer cooling in the same pipes and convectors as are used for winter heating.

When confronted with this first blackout plant, the logical prescription seemed to be to use many unit type air supply rigs and to pump hot water in winter and cold water in summer to their convectors. We knew something about heat gain from electrical input and thought that we knew something about ventilation for workmen. We learned a good deal more before we were through.

The first study of this plant suggested some 85 units spread evenly over the vast area. As information gradually was wormed out of the people who were to operate it, and as data were gained from the experience of the only similar plant in the world (which was a few months ahead of us), lo and behold the heat input was not uniform over the floor area but was exceedingly spotty and the job was found to be far more a cooling problem than a heating problem. The outcome developed into some 35 units each delivering about 35,000 cfm, each a fairly large sized central air handling system in itself, each with some distributing ducts, and each situated with reference to the manufacturing heat input and intensity of occupancy.

Heat Treating Areas

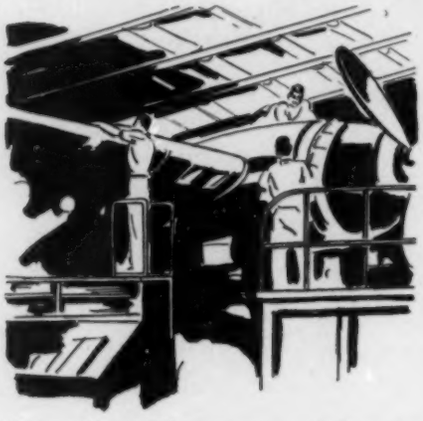
There are several large heat treating furnace areas and after some persuasion, the owner allowed us to handle them as one would treat a cooking range in a big restaurant kitchen. We built partially enclosing partitions and covers like range hoods, supplied them with air directly from outside without refrigeration, and gave them separate exhaust fans. Each "range hood" is about 100 ft long and 50 ft wide.

Such large buildings require groups of lockers and toilets; in this case there are 12 such facilities so that too long a journey to reach a washroom is not required by anyone. There is a separate forge shop building having copious mechanical ventilation, and a separate office building equipped with a direct expansion cooling system zoned for temperature control.

Samuel R. Lewis Reviews Highlights of Heating, Ventilation, and Air Conditioning of War Plants

Balance Exhaust and Supply

In a blackout building with refrigerated cooling, where some part of the air may be recirculated, an approximately balanced relation between the volume of new air from outside and the volume of air exhausted must be maintained. When capacity is installed for a million cubic feet per minute exhaust and a million cubic feet per minute supply for use on a day or



hour when 100 per cent outside air supply is desired, chaotic conditions will result if the heat removal demand from the building requires only 500,000 cfm of air from outdoors. Reducing the volume of outboard exhaust under such conditions to an extent commensurate with the thermostatically varied volume of outside supply requires considerably more attention and is much more complicated with 40 or 50 fans than is the same control with a single air conditioning system.

To meet this situation we provided mechanical exhaust only for the very hot spots, such as heat treating furnace rooms where the air supply from outdoors is not refrigerated, for toilets and lockers, and for the minimum dilution required for odor control or oxygen supply.

Cfm per Person

We have been taught to consider that around 10 cfm of new air from outside per workman, adequately distributed and with sufficient movement, is the permissible minimum. We were told by parties alleged to have power to govern us that it has now been discovered that 5 cfm of air from outside per workman is ample in any factory. I think I am reasonably self controlled and fairly generous in accepting higher authority, but this remarkable discovery did raise my internal pressure nearly to the popping off point of my safety valve.

I was compelled to spend hours making the gentleman who told me this understand that the workman was susceptible to heat, that too much heat could kill him quickly, that a building could be heated to high temperature by the heat from warm electric motors, by the heat from lathes slicing metal, and by that from grinding wheels and drills, so that we must carry away all this heat with air, and that there is a decidedly cleancut lower temperature limit to which the air which is introduced may safely be cooled.

In other words, we have found factories in operation, since the present war, with so much heat reception from processes that the entering air, in the volume which was provided, would have to be at zero temperature in order to carry off the heat and leave the workmen in an 80 deg temperature.

Therefore, in the blackout plant I started to describe with 35 conditioned air supply units, we have enough positive exhaust systems for various hooded apparatuses and the toilet and locker rooms to insure year around removal (with corresponding supply), of around 10 cfm of outside air for each workman, and have 40 or more additional outboard exhaust openings through the roof which are provided with automatic shutters to permit escape of surplus warm air from near the ceiling, but which close against air flow in the reverse direction and require a slight pressure before they open. Thus, if any or all of the air supply systems, in response to the automatic control, are forcing into the building more than the minimum 10 cfm of air per workman which the exhaust fans remove, the excess escapes through the pressure operated outboard vents.

Since the proportion of outside air to that recirculated at each air supply system varies continually, the pressure operated dampers are in constant self-adjustment, being closed only for a time on a cold morning before the production is in full swing. In terms of cubic feet per minute per square foot of floor, the average blackout machine shop with refrigerated air supply requires about 3 cfm of air compared with 1.2 cfm in an ordinary building.

Control of Temperature

Control of the temperature in this blackout plant is by outdoor thermostats serving groups of the supply systems to turn heat on the tempering convectors and to modulate the proportions of outside and recirculated air beyond a minimum set quantity in relation to the outside temperature. Additional indoor thermostats modulate face and bypass dampers for the reheating convectors. The effect in the coldest or hottest weather is to use a minimum of outside air and a maximum of recirculation, and in the average spring and fall weather to use a maximum of outside air and a minimum of recirculation. If the interior thermostats are still too warm in winter after closing the face dampers on the reheating convectors, the hot water flow to the convectors is throttled.

Reversal from winter to summer operation is accomplished by a master pneumatic switch so that, in summer, if the interior thermostats are too warm, they close the bypass dampers and open the face dampers and successively increase the chilled water flow to the convectors. As more heat is absorbed by the chilled water it causes increased refrigeration effect.

In winter, the master switch reverses the action of the indoor thermostats, cuts out the outdoor thermostats, and cuts in various aquastats and alarms to safeguard against freezing the circulating water.

There is a ruling by the industrial commission in the state where this plant is installed which prohibits installation of any ventilating system which uses hot water as the heat carrier. We had some fun getting around that narrow-minded and obsolete stipulation and hope to get the law changed against future days when its unreasonable demand would be more serious.

Control of Large Refrigeration Machines

Experience has shown that with centrifugal refrigerating compressors of 1000 ton increments it is wiser practice to control the num-

ber of machines in service manually rather than to try to do so automatically. With conventional automatic cutting in and out of such large units the tendencies to hunt and the surges caused by starting and stopping such machines are too great, and with so large a system competent engineers must be on the job anyway.

We designed for each of the two major machine shops in this plant, two 1000 ton and one 650 ton centrifugal water chilling refrigerating plants. This selection of unit sizes gives sufficient flexibility to meet any temperature condition satisfactorily, especially with the inherently flexible efficiency-capacity curve of a centrifugal compressor.

Condensing water is cooled by a mechanical draft, wood filled tower, the fan motors of which are controlled from the refrigerating room. Since the boiler plant in these particular buildings must furnish great volumes of process steam, which is lost, the refrigerant condensing plant acts as a feedwater heater for the treated boiler makeup water.

The first of the two machine shops to be completed did operate during decidedly hot weather using 100 per cent outside air before the refrigerating system was put into service, delivering about 3½ cfm of air per sq ft of floor area, and acceptable results were obtained as to interior temperature with the pressure operated relief dampers removing the surplus overheated air near the roof.

Air distribution from the supply systems in the machine shop is almost exclusively by high velocity, aspirating diffusers about 20 ft above the floor. Calculations indicate that with full production in effect, no heating from the boilers will be needed until the outside temperature is colder than 10 F, since the necessary quantity of outside air will be tempered by mixing with the recirculated warmer air until the outdoor temperature falls this far.

Economies in investment cost are made by using the piping, pumps, fans, and part of the convectors for both cooling and heating. In office buildings where we have employed this combination scheme the only criticism has been that several hours are required to change from heating to cooling.

Steam Accumulators

An unusual feature of this particular plant is that the high pressure steam boilers operate in connection with insulated steam accumulators, these being large pressure tanks which absorb into superheated water the boiler output not needed at offpeak times and which return the heat in the form of steam to the system during heavy demand by the process requirements.

Many Partitioned Spaces in Plant

We designed another new manufacturing plant devoted to war production. It requires year around control of temperature and relative humidity, involving complete refrigerated air conditioning, though it is not a blackout plant. The design started with many unit heat transfer systems receiving hot water in winter and refrigerated water in summer, with throwaway cell type air filters. As the plans progressed however, the requirements of the government and the owner daily became more arduous, and partitions kept shifting until we were confronted with the additional demands that there must be no dust such as is anticipated from dry grinding and polishing; that the building and material in course of production must be kept above 60 deg during periods of no occupancy; that the optimum temperature in each of many partitioned rooms, varying in size, would be different from that in adjacent rooms; and that the partitions must be capable of being moved as experience in future operation might require.

The best way to meet these stipulations seemed to be to change the design to several large central air supply systems, all in penthouses above the third story, each having an electrostatic air filter. The corridor ceilings were furred down to form air supply ducts, the corridors themselves were used for return air ducts, and steam heated local duct reheaters were installed at air supply inlets to the rooms at every 20 ft building bay. Thus, by controlling the duct reheaters locally with thermostats, a different delivery temperature was practicable for every 20 ft space across the long, comparatively narrow, building.

During summer, refrigerated water pumped to the central air supply systems permits delivery of air from them at about 60 deg and 50 per cent relative humidity free from dust. During winter, warmed water and controlled spray humidifiers accomplish the same result, humidity control being improved by varying the percentage of recirculated air.

The local steam heated duct reheaters increase the temperature of the delivered air to suit each individual requirement regardless of the requirement in any other bay or compartment, and during shutdown hours in winter the water circulation need not be continued; the main supply fans with 100 per cent recirculation and the steam duct reheaters do the job. This scheme permitted us to eliminate direct radiators in most of the factory spaces, though we installed them in the toilet and locker rooms. The arrangement also permitted the economical installation, for ultra-special compartments, of local recirculating fans which could secure conditioned air from the central system and locally recirculated air, mixing the two to any reasonable special condition — a result

found desirable for a few of the highly technical departments.

There is much combustible debris to be disposed of, and since we must burn preheated bunker C fuel oil, an incinerator for this disposal was built into the otherwise useless base of the radial brick chimney below the point of entry of the boiler breeching. Means were installed to conserve the heat from the burning rubbish by transfer to the domestic hot water. Condensing

water for the centrifugal refrigerating plant is cooled by an induced draft tower placed on the ground near the engine room.

Blackout Machine Shop

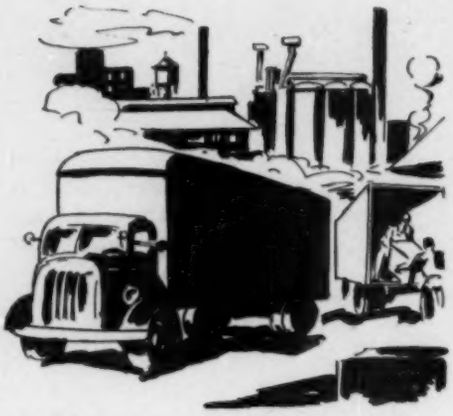
In another large blackout machine shop, the building was completed without installation of any refrigeration and without any windows. The owner made only a guess at what the electrical input for power would be. The designer of this plant did not make any allowance for probable increase by the owner in number of machines, but on the contrary took a heavy discount from the estimated electrical input as a load factor.

The plant was completed on the basis of a total electrical input of 900 hp and on the delivery of 1.2 cfm of air per sq ft of floor. The owner, while construction was underway and without telling anyone about it, changed the type of production and increased the number of machines until the actual input in electric energy amounted to about five times the originally designed horsepower. With only about one-fourth of the machines in place the interior temperature was found to increase on an 80 deg day outside to 130 deg.

Handling Oil Mist from Grinding Wheels

We were then called into the picture. The problem was complicated by the presence in the air of oil mist thrown out by the rapidly rotating grinding wheels, of which there were hundreds. Oil was collecting on the electric lights and was dripping from the overhead trusses and formed pools on the roof where it separated by impact of the air against the interior surfaces of the outboard exhaust ventilator heads. This problem of oil globules in the air has been evident in a great many of the large war production factories and has caused considerable trouble.

In most machine shop experience before the war, there have been windows and monitors and generally there has been copious mechanical ventilation, and the machines have not been so crowded together as in the recent war production plants. The modern automatic machines each generally have individual builtin coolant circu-



lating pumps and very large volumes of the oily fluid are circulated over the work.

It was not practical in this case, as it has been in some of the aircraft engine plants, to alleviate the difficulty by cutting the walls and installing windows, and by building monitors on the roof. We were compelled, therefore, to abandon the original ventilating system and to install an entirely new one capable of delivering over 4 cfm of air per sq ft of floor, with adjustable diffusers permitting a decided movement of air over the bodies of the workmen, so as to carry away the surplus heat. Our experience has been that in plants of high power input, even with ample refrigeration, that not less than 3 cfm per sq ft of floor must be delivered. With a smaller air supply than this, the entering air on a warm day would have to be too cold for comfort and would cause drafts even though maintaining an average temperature of 80 deg.

Provision was made in the redesign of this decidedly sick job for recirculation of part of the air when the temperature permitted, to take advantage in winter of the heat in the interior air for warming the air taken in from outside. Thus, the volume of outboard air thrown away must change constantly as the volume of outside air taken in, responding to temperature, is varied. We adopted the same scheme of counterbalanced gravity outlets to care for this as I have already described, since the task of balancing the suction of exhaust fans to varying proportions of outside air intake would be very difficult. There are about 27 of these outlets, each strategically placed above a zone of greatest electrical heat input. It is not expected that any heat from the boilers will be required until the outside temperature is down to about 10 deg above zero.

While dilution of the interior air by the increased volume of outboard exhaust will alleviate the problem of oil haze and dripping, it cannot solve the problem. After some experimentation and after securing the benefit of the experience of similar plants (none of which, however, completely solved the matter) a radical prescription was determined upon. It was influenced largely by our own experience in 1940 at a screw company. In this case, the wall propeller exhaust fans originally installed had deposited so much oil on the screens and louvers and wall that it ran down the wall and formed pools in the alley pavement behind the machine shop. We installed in 1940 a system of hoods and exhaust ducts leading to a centrifugal exhaust fan which discharges at high velocity into a cyclone. Inside the cyclone are graded gutters, and the top of the cyclone has similar interior gutters. The oil particles impact on the metal and the ultimate discharge is nearly oil free. Only after this was in acceptable service did I learn that some success had been achieved by others in similar cases, but with the cyclone on the suction side of the centrifugal fan rather than, as I had it, on the discharge side.

However, in this screw company case, the oil concentration was comparatively low and the volume of air exhausted through the hoods above the machines was exceedingly high, considered in relation to the 1942 blackout plant problem.

Our solution is to build an oil removal system after the general pattern of a dry dust or shavings exhaust system, with a high velocity, small volume, close fitted hood at each machine, having ducts leading from the hoods to several decidedly husky central exhaust fans.

At the screw company job, we found that the exhaust ducts themselves accumulated oil which was happy to fall out or be slapped out of the air at every point of impact. This tendency would create a fire hazard in the nonfireproof 1942 plant and it would be difficult to make the exhaust ducts oiltight. The oil itself should be capable of

reuse and should not be sent to the sewer. Therefore, as a part of the hood of each machine in the 1942 plant, we arranged an electrostatic separator cell, with a drain from its basin directly back to the oil reservoir of the machine, where the grit can settle out and the oil can be recirculated.

The long exhaust ducts therefore merely carry cleaned air which will not impose the difficulties of fire hazard or oil leakage. As far as I can learn, this scheme embodies a new solution of a very serious problem though it does seem startling to filter the air we throw away rather than—as usual—to filter the air we take into the building.

No small part of the patriotic forbearance necessary in wartime was exercised when priorities authorities insisted that no direct radiators, even of cast iron, could be used in the large office building connected with this plant. The plant does only war work, but it was stipulated that we must heat the many rooms of varying size, different intensities of occupancy and three sided orientation, entirely by hot air, the air heated by warm water, using ducts and grilles made of something other than metal. Also, we could design on the basis of delivering only 5 cfm of outside air per person.

Ventilation for Remodeled Building

In another case we remodeled a long, vacant, two story, fireproof existing building, about 400 ft square, for high intensity machine work. The original building had enough window openings to have been passed 20 years ago by the city health department, provided credit was taken for every possible square inch of window and provided that the square feet of floor occupied by columns and interior walls were deducted.

In the revised occupancy, however, a few windows were lost, so that under 1942 ground rules, mechanical ventilation became necessary. All concerned preferred, if possible, not to invoke federal government supremacy over the local code requirements. Also, even though there might be nearly enough window openings to comply with the letter of the law, the very large interior areas far away from the windows would not benefit from the windows and the resultant temperature and odor conditions might be intolerable.

The production requires an electroplating department about 150 ft by 50 ft in size from which exhaust of air carrying dangerous fumes at the rate of over 60,000 cfm is required. This air must come from outdoors and must be heated to at least 70 deg in the coldest weather.

The usual difficulty regarding purchase of new radiators, convectors, fans, and motors was present, though the plant is entirely for war offense purposes. Fortunately there was a large pile of unused cast iron indirect radiation and a fan which formerly supplied the 100,000 cfm of air exhausted by some paint spray booths. There were also many recirculating unit heaters in various former departments which could be replaced by radiators. Twenty-six of the centrifugal fan type unit heaters were rebuilt, with new casings and dampers and controls, so as to deliver into the first story around three sides of the great room about 100,000 cfm of air. This air then is drawn across the interior spaces, thoroughly wiping them out, and passes through no-backdraft shutters into the plating department and into the toilets and lockers and other spaces which require mechanical exhaust.

Every square foot of old sheet steel duct work was rebuilt and reused, supplemented by nonmetallic sheets set in crimped steel flanges.

PERCENTAGE OF FUEL OIL TO USE DURING WINTER

THE EDITOR—

Have you published, or do you know where I may obtain, a curve showing building heat requirements in New York as a cumulative in percentage? That is, for example, suppose that a given building uses 10,000 gal of oil per year, what percentage is used in October, November, December, etc.

By plotting his month by month oil consumption in percentage of his total allotment, a person could thus determine whether or not he would be able to get through the year.—G. H. G.

REPLY—

The normal degree day figures given in the ASHVE's Heating, Ventilating and Air Conditioning Guide by months for various cities may be used to arrive at this. The table shows, for New York, the month, the degree days for that month, the cumulative total degree days and the cumulative percentage.

It should be pointed out, of course, that these degree day figures are normals and must be adjusted for variations this year from the normal. Degree day figures for the current year are given in form 1030 of the local U. S. Weather Bureau stations.

Month	Degree Days	Cumulative Total Degree Days	Cumulative Percentage
October	270	270	5.25
November	624	894	17.4
December	930	1824	35.5
January	1057	2881	56.1
February	944	3825	74.5
March	846	4671	91.0
April	468	5139	100.0

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UNCLE SAM WANTS YOU TO FIGHT WASTE!

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THE DRYING OF FOODS

Rapidly Expanding Wartime Demand for Dried Foods Forces Plant Engineers and Operators to Become Familiar with Principles and Methods . . . W. R. Marshall, Jr., Tells What to Consider in Selection of Dryer

SUMMARY — The rapidly expanding demand for dried foods [at the present writing, the government is requesting a fourfold increase in the production of dried vegetables alone] to meet Army, Navy, and lend-lease requirements is forcing more and more plant engineers and operators to become familiar, in a relatively short time, with the field of drying and its ramifications. It has been the purpose of the series of articles, of which this is the fifth, to present a general picture of industrial drying practice and theory, and to show how they may be applied to food drying in order that those who are becoming acquainted with problems of drying for the first time may be able better to understand the underlying principles involved. The present and subsequent articles will consider the problems involved in the selection, design, and operation of dryers which are adaptable to the drying of foods. . . . The author has specialized in the subject of drying, and is connected with the technical division of the engineering department at E. I. du Pont de Nemours & Co.

IN THE selection of any dryer, two factors must generally be considered first before other items, the handling characteristics of the material to be dried, and the production capacity desired. The handling characteristics of the material will determine the type of dryer to be selected from the standpoint of the method by which the product is supported and/or conveyed during drying. Thus, for a free flowing, solid food a dryer may be selected from among several suitable types. However, for a liquid or a sticky, gummy mass difficult to handle there is a definite restriction on the number and types of dryers available. In general, the capacity requirement determines the kind of dryer from the standpoint of operation (batch, semi-continuous, or continuous) as well as the ultimate size. The characteristics of various types of dryers were discussed on pp. 588-591 of the October HPAC and a table showing the various methods of material handling and the usual capacity range for each dryer was presented.

Other considerations must generally be given to the selection of a dryer, but these are usually specific in nature and will depend on such factors as labor supply, type of plant operation, anticipated future production, the specific properties of the food being dried, and the relation between first costs and operating costs for the particular plant in question.

Let us consider briefly each of these additional items in more detail:

Labor Supply

The problem of adequate labor supply may be the factor which will influence the choice between a batch operated and a continuously operated dryer. If labor is scarce, as is the case under the present wartime conditions, then it is very often a necessity to select a continuous type dryer, if the capacity demands justify this choice. Even if only a low capacity is required, it is sometimes possible to schedule the plant operations so that a continuous dryer will be feasible. Sometimes, also, labor costs are such that a continuous dryer can be shown to be more economical from a comparison between first costs and yearly operating costs.

Type of Plant Operation

If the entire plant process is to be one in which there is a continuous flow of food, then it follows that a continuous type dryer should be considered. However, if the process is intermittent, or if the total daily production may readily be held in a dryer of reasonable size, then batch operation should certainly be considered. In addition, if there is a likelihood of using the dryer for more than one kind of food, then the problem of cleaning and easy adaption to the different foods must be considered.

Anticipated Future Production

Consideration of anticipated future production involves foresight of future demands as well as judgment regarding the relative permanency of the process. Thus, if a greater capacity is anticipated in the future, then consideration should be given to the type of dryer which will furnish or can be made to furnish the increased capacity at that time. Likewise, if it is anticipated that the process will become permanent, then it is highly important to select a dryer which is scientifically constructed by experienced designers and manufacturers in order that reliable and economical operation may be assured over a long period of time.

Specific Properties of the Food

This item will involve such matters as temperature sensitivity of the food, the discharge of objectionable odors, the range of moisture contents to be encountered, and the final product quality desired. Both temperature limitations and odor nuisance may warrant the selection of a vacuum dryer. A temperature sensitive material may also be dried in a continuous dryer having proper temperature control

instruments. When a material is dried to relatively low moisture contents, it is generally true that a continuous dryer will be better suited from the standpoint of more economical heat consumption. The matter of product quality involves uniformity of drying and controlled conditions during drying, both items in themselves requiring a scientifically designed dryer and the installation of the proper control instruments, all of which are reflected in a higher initial cost.

First vs. Operating Costs

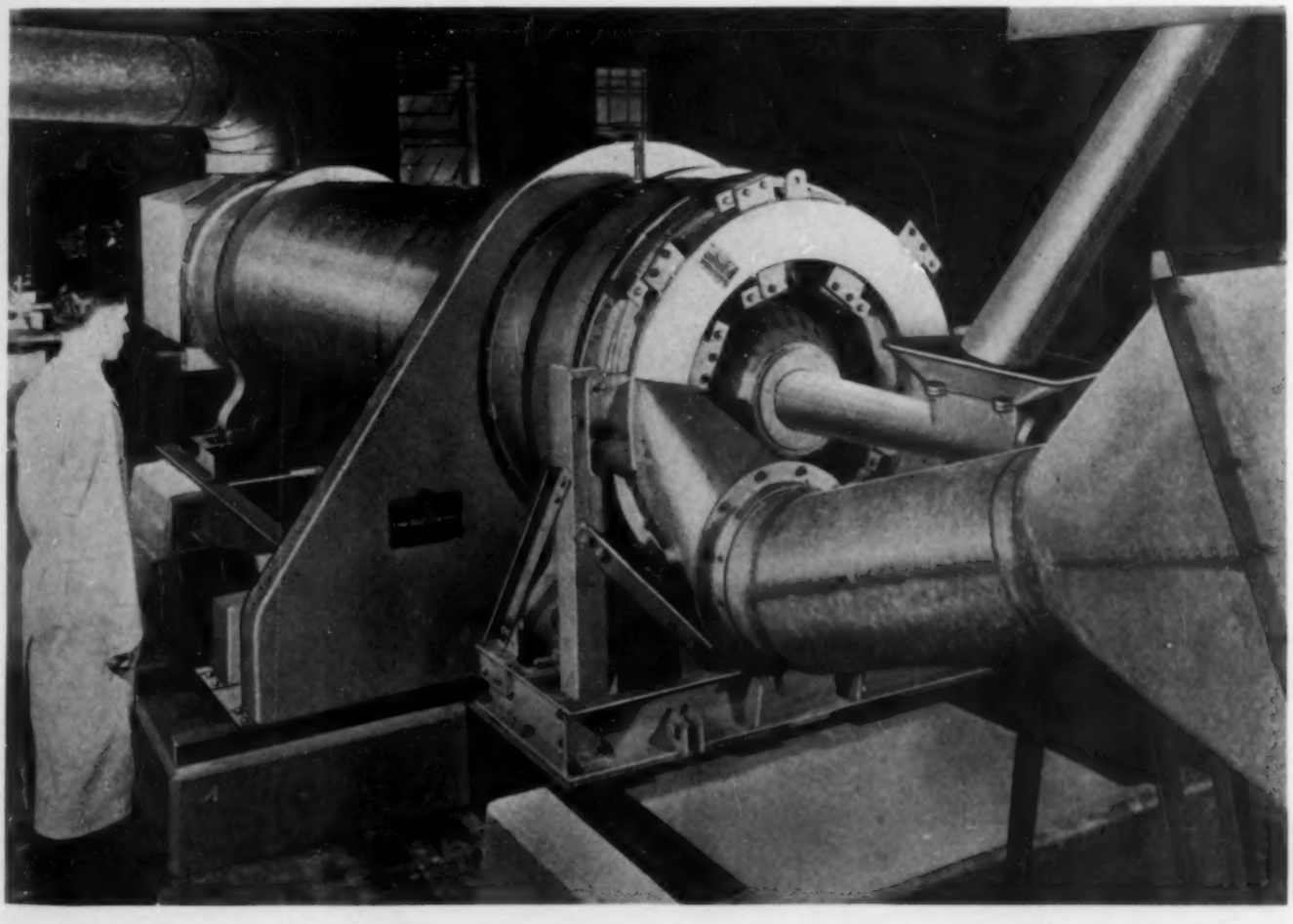
It is evident from the great variety of "home made" dryers existing in the various industrial plants today that drying has been regarded as a relatively simple operation which can be performed by any means which is readily available. This attitude has led to some operating headaches which have involved expenditures and delays far out of proportion to the operation involved, not to speak of the resulting unsatisfactorily dried product.

It is important, therefore, to realize that it is both economical and practical to approach the drying operation from a fundamental engineering basis, and that it is better practice to tolerate comparatively high first costs in lieu of the benefits to be derived from low operating costs and more satisfactory operation and maintenance. It is true that small manufacturers cannot always follow this procedure, and for this reason it is to their advantage to understand the fundamentals of drying in order to be able better to analyze their dryer operation and thereby improve it.

The Design of Dryers

The scientific design of a dryer requires, first of all, complete information concerning the physical and chemical properties of the material to be dried. It is surprising to find how many manufacturers are ignorant of their material's properties which are important to the design of the dryer. Usually some vague figure regarding the permissible drying temperature is given, although it often happens that the actual permissible temperature may be considerably in excess of the one specified. The initial moisture content is another variable which is not always definitely fixed, so that a dryer should be designed to handle the maximum moisture removal load which is liable to be encountered. Fortunately, in the case of foods, a great deal of excellent fundamental research on the drying characteristics of foodstuffs, especially vegetables, is now in progress in the U. S. Department of Agriculture, so that those entering this drying field may avail themselves of the data obtained concerning the proper conditions of drying.

This specially constructed rotary dryer is being used by Swift & Co. for the drying of meat for shipment overseas. Precooked, finely ground meat is fed into the near end of the cylinder by automatic feeding machinery. The cylinder revolves slowly and the granular product inside tumbles slowly over a bed of louver plates between which the warmed air, at controlled temperatures, penetrates the meat evenly. The meat sifts down the slight decline of the tube and out the far end into hoppers, from which it is conveyed to packaging machinery



In general, the following outline of information should be available before the final design of a dryer is undertaken:

1). Temperature characteristics of the food.

2). Specified initial and final moisture contents.

3). The available plant heat supply should be known so that the dryer will not be designed for heat requirements which cannot be supplied.

4). Power facilities must be known for the proper selection of motors.

5). Desired production capacity in lb per hr of dried product.

6). The building layout where the dryer is to be placed should be known.

7). The problem of corrosion must be considered in selecting the materials of construction.

8). The floor construction must be considered from the standpoints of heat losses through the bottom of the dryer and of the weight on the supporting members.

9). The manner in which the food is to come to the dryer should be known.

10). Will temperature and humidity controls be used?

11). Is compressed air available to operate controls?

12). How are the fans to be driven?

Drying Time and Drying Rate

It is apparent from the foregoing items that the proper design of a dryer involves a number of preliminary considerations. It should be pointed out that information on the all-important factor of drying time or drying rate was not listed, since this warrants special consideration.

One of the major objectives in drying research has been to discover some means of predicting drying rates from the known properties of the material and the external drying conditions. However, no general procedure for doing this has as yet been developed, so that it is generally necessary to determine the drying time or drying rate of a material by means of experimental tests. Ideally, it would be desirable to make a series of experimental tests from which equations could be developed to show the influence of all variables on the drying rates. This is generally prohibited by time limitations, so that usually only enough tests are made to determine the best conditions of drying and to obtain the necessary design data. In all such tests it is imperative to duplicate as nearly as possible the conditions which will be met in the actual dryer. Thus, if a tray or compartment type dryer is to be designed, the drying test should be one in which air blows across the tray of material, and the temperature and humidity of the air should be the same as those to be used in the large scale dryer. Or, if the dryer to be designed is a conveying screen type in which air circulates through the material, then the experimental test should duplicate this condition, as well as any temperature changes which may occur during the passage of the food through the dryer. Likewise, only experimental tests on small scale rotary dryers, drum dryers, or spray dryers can be used for the design of their respective large scale prototypes.

In subsequent articles, it will be our purpose to illustrate the methods used in determining the size of a dryer, the air and fan requirements, and the heat requirements. It would be impossible to consider a complete design of all types of dryers. However, a detailed design of one type of dryer will be presented, while the methods of making rapid high spot design estimates of the sizes of other types will be indicated in less detail. The types of dryers which will be considered are the tray or compartment dryer, the tunnel dryer, the conveying screen or through-circulation dryer, the rotary dryer, the drum dryer, and the spray dryer. In each case, the usual methods of operation will be considered and discussed.

DRIED FOODS "FOLLOW THE FLAG"

¶ Powdered lemon juice and cocoa have been substituted for coffee in two of the three canned packages of the B unit in the soldiers' emergency field ration C, says the War Department. This change will save two-thirds the amount of metal formerly used, since coffee had to be packed in an individual container to preserve it. The content of each package is sufficient to make one pint of beverage.

¶ A "five in one" canned ration, including ham and eggs, has been developed especially for units of motorized and mechanized forces, according to the War Department. It consists mainly of canned and dehydrated foods. The ration includes three full meals for five men for one day. Cooking ability is not required. When necessary the can is heated and the food is ready in a few minutes. Dietitians of the Quartermaster Corps, who developed the new ration, have worked out three daily menus, each containing approximately 4000 calories.

¶ Four new dehydrated foods, including baked beans, are on menus for United States troops overseas, the War Department has announced. The other foods, developed by the Army's Quartermaster Corps, are prune powder, apricot powder and a swiss cheese soup. All the cook has to do is add water, heat, and serve. Prior to drying, the beans are baked. Four ounces of dehydrated beans are equivalent to 12 ounces of regularly cooked beans. The cheese soup contains dry, powdered milk, potato, oat, and soya flours in addition to the cheese. Flavoring ingredients, such as onions, celery and parsley salts are added. The soup is precooked. The prune and apricot powders are used as bases for making jams. Sugar and water are added to provide spreads, replacing jams and jellies.

¶ The latest addition to the list of dehydrated foods for troops overseas is rice pudding, the War Department announces. In its concentrated form the pudding is a mixture of precooked rice, processed raisins, sugar, salt, spices, and vanilla flavoring, in proper proportions. It requires only the addition of water and cooking to convert it into a tasty dessert. The rice is precooked until it contains not more than 10 per cent moisture. When water is added it returns to its original grain character and produces a pudding that looks and tastes like ordinary grain rice.

Court House System Combines Panel Heating and Cooling, Conditioning

Erwin L. Weber, Consulting Engineer, Explains "Environment Conditioning" System Design and Operating Method

SUMMARY—Until wartime applications, problems, and restrictions took the center of the stage, panel or radiant heating and cooling were among the subjects given prime attention by engineers and contractors. Radiant heating—and cooling—are finding a number of interesting war uses, and the method is expected by many to enjoy increasing popularity in the tremendous peacetime construction to come . . . . Described here in some detail is an unusual installation combining panel heating and cooling and air conditioning, which serves the Yakima County, Wash., court house

THE YAKIMA County, Wash., court house has a complete "environment conditioning" system, comprising air washing, filtering, and tempering, and panel warming and cooling. In the design of the system, full advantage was taken of the peculiar climatic conditions prevailing in the region.

Yakima is in the rain shadow of two great mountain ranges, the Rocky mountains to the east and the Cascades to the west. It therefore has a semi-arid type of climate. The winter mean average minimum temperature is 20.8 F for January and the absolute minimum temperature is —24 F. The summers are hot and dry, with a mean average maximum temperature of 88.9 F for July and an absolute maximum temperature of 111 F. During the summer, the dew point temperature seldom exceeds 50 F. Well water at 55 to 56 F is available at a depth of about 250 ft.

The Boiler Plant

The central heating plant is in the basement of the jail section and comprises a hot water boiler with a stoker. Two future boilers are allowed for. Domestic hot water is generated in a 960 gal steel storage tank having a copper coil with 120 sq ft of heating surface, and is circulated through the building by a 1¼ in. by 1 in. motor driven pump. The circulating pump for the heating system has a capacity of 250 gpm against a static head of 30 ft and is direct connected to a 5 hp motor. The closed expansion tank is 36 in. by 96 in.; it is designed for 50 psi pressure.

Flow and return mains, a cold well water main, and a waste water main extend from the boiler room to the basement of the court house.

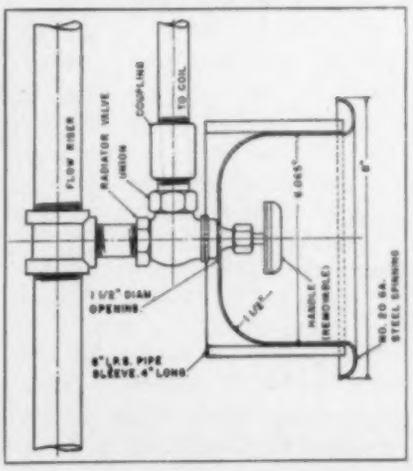
27,000 Feet of Pipe Coils

The panel heating and cooling system contains over 27,000 lineal feet of ½ in. pipe in 189 coils. The coils on the first and second floor are embedded in the concrete floor slabs and those on the third floor are installed in the suspended plaster ceiling.

The system has seven zones — north, east, south, west, court room No. 1, No. 2, and No. 3. The supply main for each zone is derived from a three way diaphragm mixing valve connected with the hot water from the converter and with the return water. These flow mains are on the basement ceiling. Branches from the risers have valves with special valve handle enclosures set in the outside walls and are connected to each coil or group of coils.

The return riser from each panel coil extends to the attic where it is connected through an equalizing non-reflux elbow *ENRE* to the return mains, which pitch to two expansion tanks in order to relieve all air automatically. The returns from the expansion tanks connect with the circulating pump, from which the discharge has one branch to the inlet of the converter and another branch to supply the seven mixing valves with unheated return water. The system was completely balanced by the use of an electro-differential thermometer.

Detail of valve handle enclosure used on the panel heating and cooling system. According to the specifications, the spinning should fit snugly into the pipe sleeve and should be finished with a gray filler priming coat. The pipe sleeve must be absolutely concentric with the axis of the valve stem



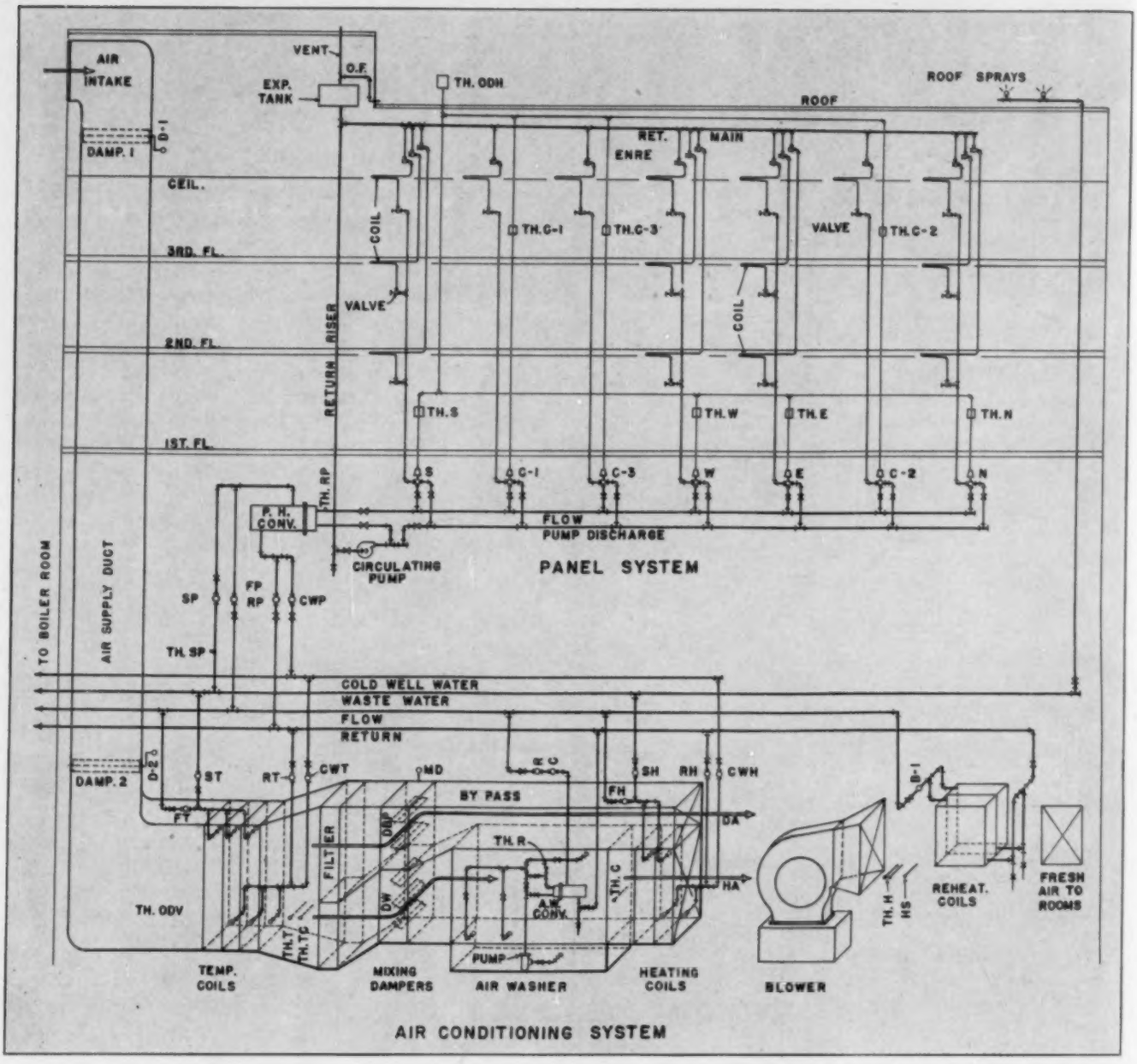
The converter is of the countercurrent type and has 50 sq ft of copper heating surface and a capacity of 1,800,000 Btu per hr. The circulating pump has a capacity of 185 gpm against a head of 40 ft and is direct connected to a 5 hp motor.

There are only six radiators in the building. These are installed in the jury dormitories and are connected on the domestic hot water system to be used only for heating the dormitories at night after the panel heating system is shut down.

Ventilation and Air Conditioning

The ventilating and air conditioning system comprises an air washer of 20,000 cfm capacity, 9 ft long, with two sets of spray nozzles and one set of flooding nozzles; an air filter; three banks of tempering coils; and two additional two-bank reheating coils for heating and ventilating the basement. The blower is of the double width, double inlet type and has a capacity of 17,500 cfm at 1¼ in. water gage, geared with a v belt to a 7½ hp motor. In the penthouses are two exhaust fans, each with a capacity of 7500 cfm at ¾ in. water gage, connected by v belts to 3 hp motors.

Conditioned air is introduced into all rooms along the outside wall under windows, etc., and is discharged downward through diffusing registers. Vitiated air is exhausted over the doors to foul air ducts installed over the suspended corridor ceilings, from which it is discharged by the two exhaust fans.



This diagram of the panel system and the air conditioning system shows the various thermostats, dampers, valves, and other equipment for both winter and summer operation. The functions of the various parts are described in detail in the text. ("O.F." is the overflow from the expansion tank)

How System Operates

Water for the panel system is warmed or cooled in the panel heating converter (*P.H. CONV.* on drawing) and discharged to the flow main. The returns enter the circulating pump which feeds the converter and the pump discharge line in multiple. The flow water to the seven heating zones is derived through the seven three-way diaphragm mixing valves connected to the flow main and to the pump discharge main. Each mixing valve is controlled by a thermostat to mix flow and return water in the proper proportion as demanded by its respective thermostat.

Outdoor thermostat *TH.ODH* changes the system from heating to cooling operation. During the heating operation valves *FP* and *RP* are opened by thermostat *TH.ODH* to permit flow water from the boiler to pass through the shell of the converter, and valves *SP* and *CWP* are closed. Insertion thermostat *TH.RP* in the flow line from the converter is set at 130 F (maximum permissible temperature) and operates gradual acting diaphragm valve *FP*, which is reverse acting, to close automatically in case of failure of air pressure and thus avoid accidental overheating of the panel coils. During the cooling operation, valves *CWP* and *SP* are opened by thermostat *TH.ODH* to permit cold well water to pass through the shell of the converter, and valves *FP* and *RP* are closed. Insertion thermostat *TH.SP* in the waste water line operates valve *SP* and is set at 64 F, or other desired discharge temperature of the waste water.

Outdoor thermostat *TH.ODH* also automatically switches room thermostats *TH.S*, *TH.C-1*, *TH.C-3*, *TH.C-2*, *TH.W*, *TH.E*, and *TH.N* between summer and winter operation. These thermostats are all of the remote readjustable summer and winter type. This is necessitated by the requirement that the direction of flow of the water in

the panel system must be the same during summer or winter operation to relieve effectively the air upward to the expansion tank.

The outside air enters at the roof level and passes through the air supply duct and the two felted dampers *D-1* and *D-2*; these dampers are operated by solenoid air valves connected to the blower motor, to open when the motor is started and close when the motor is stopped. The fan motor is also stopped by an insertion thermostat and relay when the temperature of the return water from the tempering coils falls below 38 F. This automatically closes the intake dampers and serves as an additional precaution against the freezing of the tempering coils.

The air then passes through the tempering coils. Outdoor thermostat *TH.ODV* changes the system from heating to cooling. During the heating operation, valves *FT* and *RT* are automatically opened by *TH.ODV* to permit flow water from the boiler to pass through the tempering coils, and valves *CWT* and *ST* are closed. Thermostat *TH.T* is set at 50 F and controls gradual acting valve *FT* in the flow line to the tempering coils. During the cooling operation, valves *CWT* and *ST* are automatically opened by *TH.ODV* to permit cold well water to pass through the tempering coils and valves *FT* and *RT* are closed. Thermostat *TH.TC*, adjustable from 50 to 100 F, controls gradual acting valve *CWT* in the cold water line to the tempering coils.

From here the air may pass through the filter and bypass as dry air (*DA*), or it may pass under the filter and then the air washer as humidified air (*HA*), in varying proportions, depending upon the positioning of the interconnected dampers *DPB* and *DW*. These dampers are operated by the diaphragm valve *MD*, which is controlled by humidistat *HS*, or may be manually controlled from the system switchboard to maintain any desired humidity.

Air stream *HA* passes through the air washer, wherein the spray water is heated in the air washer converter (*A.W.CONV*) which is heated by the flow water from the boiler, controlled by thermostat *TH.C* operating gradual acting valve *C* set at 50 F (dew point control). Insertion thermostat *TH.R*, set at 78 F, operates the reverse acting valve *R* and acts as a safety valve to prevent overhumidification of the air if valve *C* becomes inoperative or in case the air pressure fails.

Air stream *HA* next passes through the heating coils. Outdoor thermostat *TH.ODV* adjusts the operation of the coils to heating or cooling operation. During the heating operation, valves *FH* and *RH* are automatically opened by *TH.ODV* to permit flow water from the boiler to pass through the heating coils, and valves *CWH* and *SH* are closed. One point of the two point thermostat *TH.H*, set at 70 F, controls gradual acting valve *FH* in the flow line to the heating coils. During the cooling operation, valves *CWH* and *SH* are automatically opened by *TH.ODV* to permit cold well water to pass through the coils, and valves *FH* and *RH* are closed. The second point of two point thermostat *TH.H*, adjustable from 50 to 100 F, controls gradual acting valve *CWH*.

Reheating coils *B-1* and *B-2* (not shown) are for the air conditioning system for the basement and are controlled by room thermostats in the basement operating gradual acting valves *B-1* and *B-2* in the flow lines to the coils.

Waste Water for Roof Spraying

The waste water from the system during summer operation is used for spraying the roof for its evaporative cooling effect, and for lawn sprinklers. It also supplies the waste water header in the boiler room, which is provided with a relief valve set at 55 psi, and has two branches with diaphragm valves interconnected with two similar branches from the cold well water header. One branch supplies water to the boiler room and hot water tank and the other branch is used for flushing the water closets in the jail. Each of these two lines is arranged so that the valves in the waste water lines open and the valves in the cold well water lines close when the pressure in the waste water line rises to 50 psi, and vice versa when this pressure falls below 50, to utilize waste water whenever available.

The well contract has been let for a 12 in. and 10 in. cased well (12 in. as far as possible, reduced to 10 in. thereafter), 250 ft deep, with a pump having a capacity of 850 gpm against a head of 200 ft. The motor is of 60 hp capacity. Due to wartime restrictions the well installation has not been completed. However, city water at 65 F was used in limited quantities last summer with noticeable cooling effect.

The building was designed by Francis H. Fassett and H. Don Gouchenor, architects. The electrical, mechanical, and sanitary equipment was designed by the author. Ben Drinkwater was contractor for the heating and air conditioning system. The panel heating and cooling system was licensed from Richard Crittall & Co., Ltd., through Wolff & Munier, Inc.

65 F SAFE FOR HEALTH, DR. PARRAN SAYS

The 65 deg temperature that government war agencies have asked Americans to maintain in their homes is well within not only the health zone but even the comfort zone, according to Surgeon General Parran. In European countries, Dr. Parran said, with winter temperatures comparable to those of the eastern and northeastern United States, winter temperatures in the homes are maintained far below ours, with no evidence of increase in respiratory or other diseases which would be likely to result therefrom.

In the absence of scientific data on the subject, Dr. Parran gave it as his best opinion that—

1) A room temperature of 55 F would not result in any material impairment of public health.

2) Room temperatures ranging from 45 to 55 F would result in a slight but not serious danger to public health.

3) Room temperatures below 45 F would seriously endanger public health.

Dr. Parran's figure of 55 deg, which he said would not materially impair public health, is 10 deg lower than that for adults requested by government war agencies.

Piping and Cooling QUENCHING FLUIDS

F. F. Stevenson and N. U. Stryker Describe Cooler and Piping Layout for Handling Both Oil and Water Quenches Required in the Heat Treatment of Steel

SUMMARY—Messrs. Stevenson and Stryker—of J. P. Baldwin Co. and the Accurate Steel Treating Co., respectively—describe here a rather unique layout utilizing an atmospheric spray tower for cooling both water and oil for quenching, as required in the heat treatment of steel. Automatic temperature control is also discussed, and the importance and method of providing turbulence in the oil quenching tank are explained . . . The authors conclude with brief mention of other methods of cooling quenching oil

WITH THE heavy wartime demand for heat treated steel of all descriptions, cooling the quenching oil and water become of increased importance. The manufacturers of heat transfer apparatus have provided much excellent equipment for cooling hot oil and hot water and offer a variety of methods.

The system described in this article is rather unique, inasmuch as it uses one cooler to cool both hot quenching water and hot oil. The cooling tower part of the cooler acts to cool the water, and the coil surface serves to cool the oil. This is an economical arrangement for a process in which the quenching water does not have to be at too low a temperature and in which the quenching tank is not too heavily loaded. The plant using this equipment is one which heat treats a large variety of steel and alloy parts, varying in weight from a fraction of a pound up to a ton.

Two quenching tanks are served by the cooler; one uses oil and the other water. They are the same size, 6 ft long by 4½ ft wide by 8 ft deep. They are equipped with the conventional screens, which can be raised or lowered by hand. The normal liquid level is maintained about 18 in. below the top of the tanks, giving them a capacity of about 1300 gal each. Both have the usual overflow arrangement, keeping the liquid level constant.

When bubble of hot oil vapor reaches the surface of a quench tank, it may break into flame at once. Turbulence will prevent this, so a separate pump is used to create turbulence

The Water Quencher

In the case of the water quencher, the hot water from the tank is pumped directly to the cooler (which is situated on the roof above) through a 3 in. pipe line by means of a 125 gpm centrifugal pump direct connected to a 5 hp motor. This pump is run continuously, except in cold or freezing weather, and is manually controlled.

In cool weather there is no difficulty in maintaining the quench water at proper temperatures even when the peak load on the tank is exceeded. The water quench tank was designed to handle 2000 lb per hr of steel. During cool weather and with normal loads, the temperature of the water leaving the tank does not exceed 80 F. In warm weather, or with especially heavy loads, water temperatures of 120 F have been recorded for short periods. Make up water from the city main is admitted into the quench tank at the rate of about 5 gpm, excess water flowing into a sewer line connected to the overflow of the tank. During periods of hot weather, or of abnormally

heavy loads, the amount of make up water is increased to 40 to 50 gpm. As the city water temperature rarely exceeds 70 to 75 F, it is of considerable assistance in keeping the outlet water temperature from reaching too high a figure. The make up water also helps in keeping the water circulating in the system clean. However, during most of the time this extra make up water is not needed, the cooling effect of the single cooler being sufficient for both the water and oil.

The Oil Quencher

In the case of the oil quencher, the hot oil flows through the overflow and by gravity into a 2000 gal underground storage tank which is situated a few feet below the floor level and normally contains about 1500 gal of oil. A 3 in. pipe line connects the tank to the suction intake of the oil pump. The pump is of the vertical type, self priming, has a capacity of 125 gpm, and is driven by a direct connected 5 hp motor. The suction intake of the pump is about 7 ft above the oil level in the tank and this makes the use of a self priming pump essential. There is a strainer at the end of the oil suction pipe, but no foot valve is used.

The pump takes the oil from the reservoir tank and brings it up to the base of the cooler, which is on the roof about 35 ft above the pump.

Cooler Is Spray Tower

The cooler is a standard atmospheric spray tower with oil cooling coils placed in the bottom. Tubes are 1¼ in. copper, staggered to provide ample air and spray turbulence; cast iron spacers are used and the headers are finned. The coil provides three oil passes, with the inlet and outlet at opposite ends.

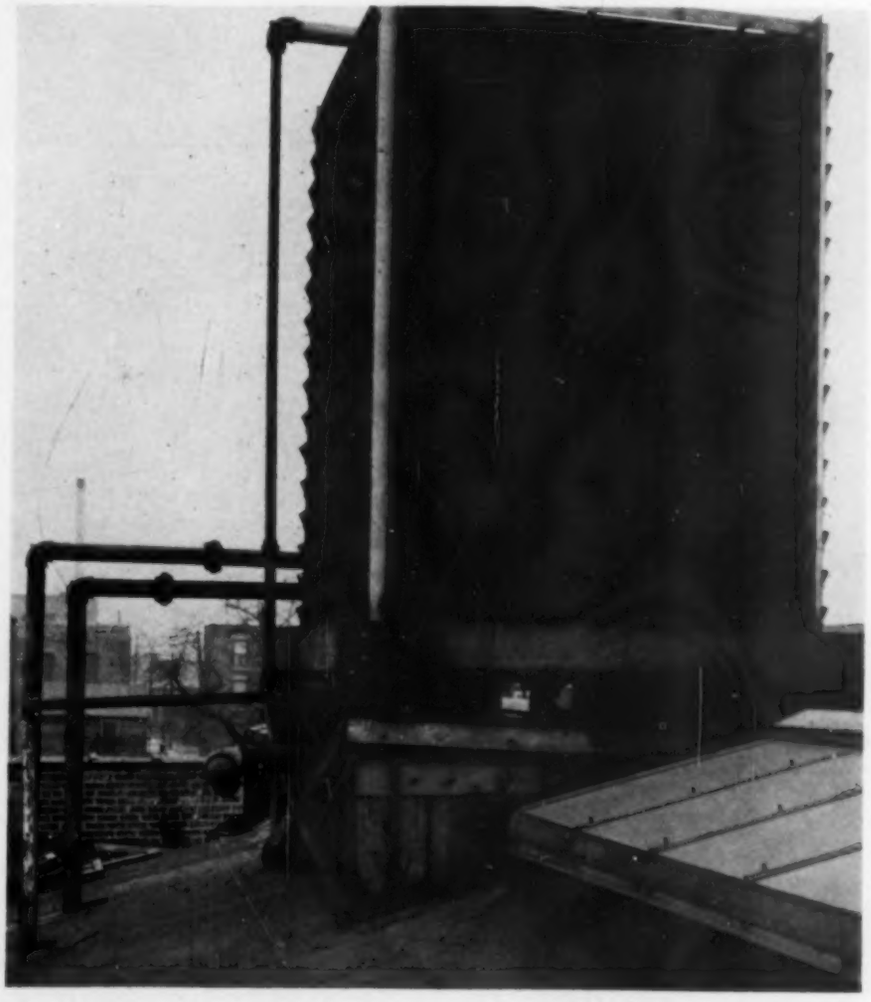
The water from the water quench tank is brought to the top of the cooler and sprayed downward through special nozzles. Disregarding the oil cooling coils for a moment, the tower acts as a water cooler, with the water temperature reduction depending upon its entering condition and the wet bulb temperature of the air.

The cooled water falls on the oil cooling coils in the base of the tower and an evaporative cooling effect is obtained by the gravity flow of air over the wetted coils. The moist, heat laden air then passes out of the tower.

The oil cooling load on the evaporative cooling coils is the product of the number of pounds of oil delivered to it per unit of time multiplied by the specific heat of quench oil (about 0.5) times the cooling range (in this case, about 20 F). At peak capacity, this will be about 550,000 Btu per hr. Using the tower for the dual purpose of water cooling and oil cooling, 125 gpm of water is brought to the tower and cooled, and at the same time 125 gpm of hot oil is cooled, using the cooled water and the evaporative cooling effect. The reason that both oil and water can be cooled in the same cooler is that large quantities of water, compared to that actually required for the oil cooling alone, are employed. However, as stated before, the tower does not have sufficient capacity at greater than normal quenching loads when the wet bulb temperature is high. Then, it is necessary to supplement the action of the tower by the addition of city water. After the cooling process the oil and water are piped back to their respective quench tanks.

Turbulence in Oil Quenching

In oil quenching, turbulence is a matter of prime importance. If a red hot piece of steel is quenched in a tank of still oil, a highly inflammable envelope of oil vapor forms around the piece. This envelope breaks up into large bubbles which rise to the surface of the oil and burst into flame. As the piece cools, the oil no longer vaporizes, but the hot oil rises to the surface and—since oil is not a particularly good conductor of heat—that on the surface may reach a temperature close to its flash point. When



Evaporative cooling tower which serves the dual purpose of cooling quench water and quench oil. The oil cooling coils are in the base of the tower

the next piece is quenched, the entire surface of the oil may burst into flame and serious fire may be caused. The hot vapor envelope also slows down the rate at which the quenched piece cools and this may cause improper hardening of the steel. When the oil is constantly circulated through the tank with considerable turbulence, the above described vapor envelope is instantly washed away and the hot oil around the piece is constantly being replaced by cooler oil.

To create turbulence in the oil quenching tank, a separate pump is used to introduce and withdraw large quantities of oil into and from the tank. The pump is about 18 ft from the tank and on the same level. It is a rotary type, with a capacity of 500 gpm, and is connected by chain drive to a 20 hp motor. Discharge and suction pipe lines are both 5 in. When the pump was first installed, both the outlet and inlet connections at the tank were placed about 5 ft below the oil level, but this arrangement did not create enough surface agitation, so the outlet connection was raised so that it is only about a foot below the surface.

Automatic Temperature Control

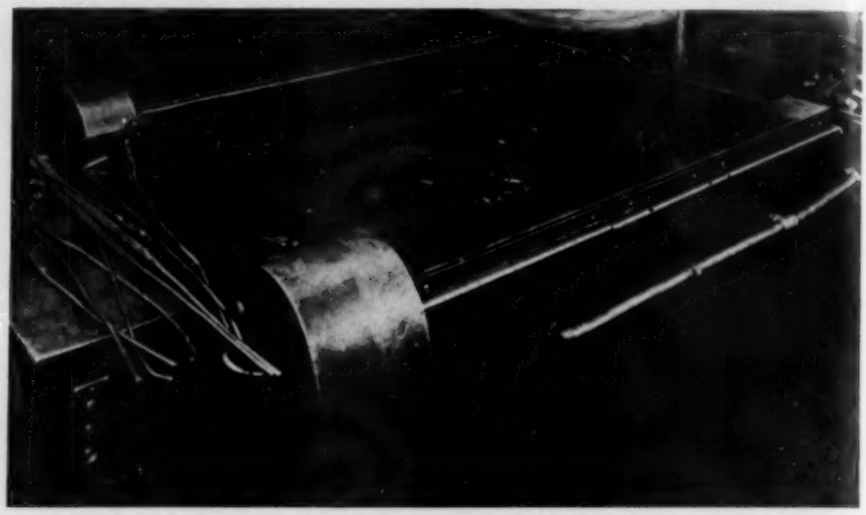
When the installation was first made, an automatic temperature control was installed as follows: A special, two stage, line voltage thermostat, having a differential of 20 F, with a remote immersion type thermal bulb, was selected and the bulb placed in the 5 in. suction pipe near the tank.

The bulb was placed in the pipe line instead of in the tank because of the likelihood of breakage in the latter location. A check showed less than 5 F difference between the oil temperature in the interior of the tank and at the bulb in the line.

The thermostat energized a relay which was wired to the magnetic starter of the 5 hp oil pump and also to the operator of a motorized valve in the 3 in. pipe near the suction intake of the pump. When the oil temperature rose to 180 F, the valve was opened and the pump started, bringing the hot oil up to the cooling tower. When the oil temperature fell to 160 F, the valve was closed and the pump stopped. The closing of the valve, simultaneously with the stopping of the pump, maintained the partial vacuum at the pump intake, prevented the oil from flowing back to the storage tank (which is open to the atmosphere) and kept a full prime on the pump. As previously stated, the pump is of the self priming type, but when it was started without the valve operation, a considerable time always elapsed before it took hold properly. With the valve action, it started at full efficiency in a few seconds.

The above mentioned control handled the temperature situation very well, with one exception. When the tank was closed down for a period over a day or a night in cold weather, the oil in the storage tank cooled considerably and tended to thicken. This caused delay in starting up. Another objection was with the tank in use and the 5 hp pump stopped, the oil no longer flowed through the overflow outlet and the foam normally formed on the oil surface did not drain off. This foam is also a definite fire hazard, so it was decided to make a change in the control system.

A bypass line was installed in the 3 in. line, so that the hot oil could either be pumped up to the cooler or bypassed back to the quench tank. The motorized valve was removed from the suction intake of the pump and placed in the pump discharge line leading to the cooler. Another automatic valve was placed in the bypass line. The thermostat acts, when oil cooling is called for, to close the bypass valve and open the valve to the cooler; when cooling is no longer demanded, the operation is reversed. The 5 hp pump motor is run continuously and is controlled by hand. This arrangement has proved very satisfactory from the standpoint of oil storage conditions and turbulence in the tank, although the control of temperature is not as close as with the first method.



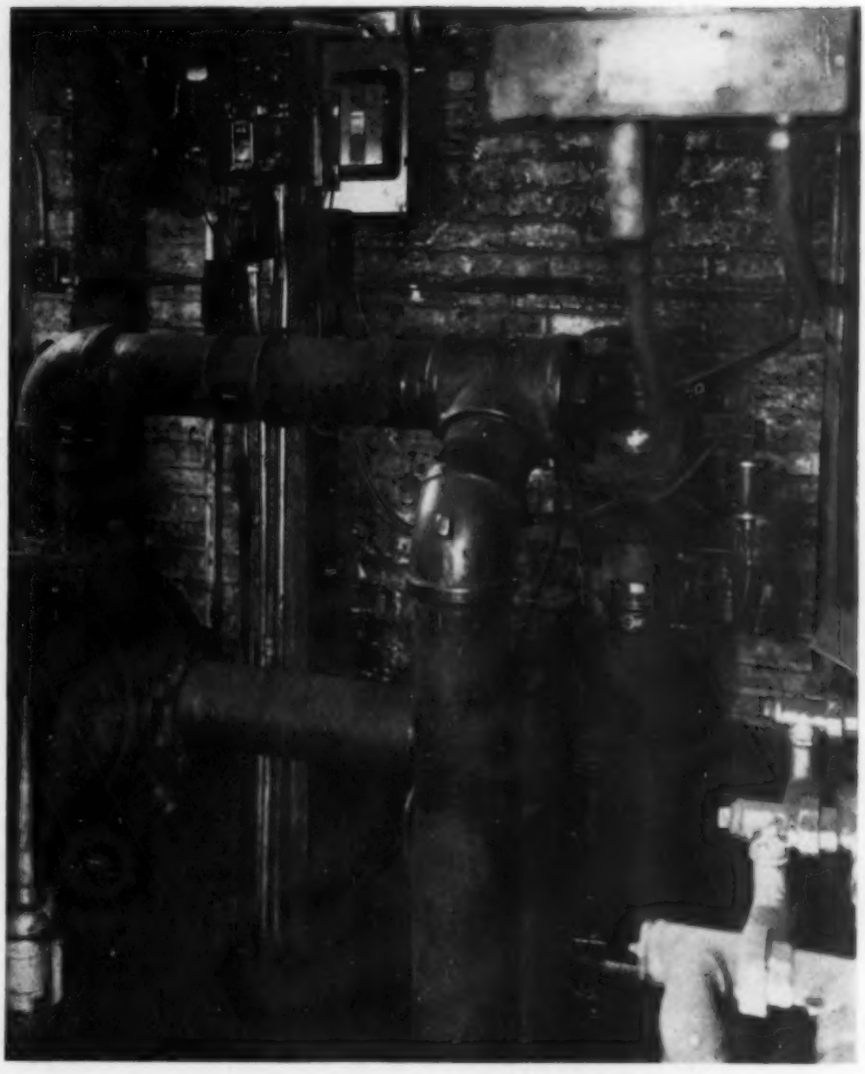
Oil quench tank having a capacity of 2000 lb per hr of steel. The screen is raised or lowered by hand

As mentioned, this system was designed to handle 2000 lb per hr of steel in either the water or the oil quench tank. However, as much as 6000 lb per hr have been quenched in the oil tank and the oil temperature has never exceeded 200 F. This speaks well for the design of the system and the efficiency of the equipment.

Other Cooling Methods

Forced circulation of air through any evaporative cooler stimulates the heat transfer rate and many manufacturers of evaporative condensers are now offering quench oil coolers, which are very satisfactory. However, if a spray atmospheric tower can be placed where it is well exposed to the prevailing winds, and if the wet bulb temperature is not too high, it will do an excellent job of oil cooling.

Where a more accurate control of temperature is desired, it may be advisable to use a cooler equipped with an automatic air bypass. Such a cooler uses a special air outlet duct, with a bypass duct leading to the air intake. A suitable thermostat is placed in the oil outlet line.



Pipe line and pump handling 125 gpm of hot oil between reservoir tank and cooling tower. One motorized valve may be seen behind the pump

which actuates a damper motor controlling a pair of dampers. During the cooling operation, as oil temperature drops, recirculated air is used, and when oil temperature rises, outside air is brought into the cooler. For winter use, when the outside air is cold, the sprays may be shut off and the tower operated as an air cooler. Sometimes it is desirable to heat the spray water and this is done by means of a steam coil or steam ejector, thermostatically controlled. This is useful for oil preheating after periods of shutdown.

Remember, in any evaporative cooler, the major transfer of heat is that required to evaporate the water film on the external transfer surface, and the greater the vapor pressure on the surface of the water film compared to the vapor pressure of the air, the greater the rate of evaporation.

When it is required to cool the oil to temperatures below the range of evaporative cooling, refrigeration must be employed. Shell and tube coolers using refrigerated water, with the hot oil passing through the tubes, or direct refrigerated surface, with refrigerant expanding in the shell, are frequently used. Sometimes an evaporative cooler is operated as a precooler before passing the oil to the shell and tube heat exchanger. Cold well water is also used in quench oil cooling.

SHOCK REFRIGERATION SAFEGUARDS FLYING SUITS

A periodic cycle of cooling and heating is proving to be the best method of protecting expensive wool and fur flying suits from moths while they are stored between flights, according to L. W. Clifford of Westinghouse Electric and Mfg. Co.

The normal storage temperature is 35 to 40 F. In the "shock" cycle, the storage room temperature is reduced to 15 F for several days to kill any larva which may be feeding. Then, by cutting off the refrigeration and introducing heat (usually from strip heaters in the supply duct or coil chamber), the storage room temperature is quickly raised to 50 F, where it is held for a *few hours only*. This causes any surviving larva to again become active and will hatch out any potentially dangerous eggs.

The temperature, after this few hour period at 50 F, is again suddenly dropped to 15 F for a day to kill off the surviving larva and any larva newly hatched. After one day at 15 F, the temperature is brought back to the 35 F or 40 F storage condition.

This entire procedure is repeated at regular intervals or, to prevent reinfestation, when any appreciable quantity of untreated articles of clothing is placed in the storage room. Relative humidity is high enough to prevent drying and cracking of the fur skin, but low enough to prevent mold or mildew. During the normal storage period, with temperatures of 35 to 40 F, the relative humidity is about 50 to 65 per cent.

Typical installations include a flying school using an open-type 7½ hp condensing unit with two-speed motor, and a horizontal type air handling unit with refrigeration coil. At one aircraft factory, three 25 hp condensing units and four air handling units with refrigeration coils are used.

SURFACE CONDENSER LIMITATION ORDER

Because control over surface condensers has been established by amendment No. 4 to WPB order L-117, announced last month by the director general for operations, such apparatus have been removed from order L-172, which formerly controlled distribution. This action is embodied in amendment No. 1 to L-172 (heat exchangers).

The amended L-117 order sets up a system of production scheduling for surface condensers and other heavy power and steam equipment.

AIR CONDITIONING GOES TO WAR

Same Equipment Used in Peacetime Now on Active Duty in All Out War Effort . . . Margaret Ingels Cites Applications

SUMMARY—Conversion to war of the air conditioning and heating industries, unlike the automotive industry, has been largely in application, has not meant the discontinuance of one product to make another. The same equipment serving industry and business in peacetime is now on the job with our armed forces, our allies, and in war production plants. . . . Miss Ingels, mechanical engineer, and engineering editor of the Carrier Corp., surveys air conditioning, refrigeration, and heating since Pearl Harbor. The many applications which the products of one manufacturer have found show dramatically and conclusively that air conditioning—and heating—have gone to war

A SURVEY of air conditioning, refrigeration, and heating for 1942 shows complete conversion from a pre-declaration of war activity to an all out effort which followed Pearl Harbor. Unlike the automotive industry, conversion for air conditioning and related equipment did not mean discontinuance of one product to make another. The conversion was almost entirely in *application*. The air conditioning units formerly used to provide comfort in offices became the units to provide workable air conditions in underground plotting rooms of Navy bases. The refrigerating units that were designed to supply chilled water for air conditioning of theaters now supply chilled water for efficient operation in war plants. Heating units used to warm store vestibules and public garages in pre-war days now heat Army barracks and factories not requiring conditioned air.

Table 1 illustrates the conversion in application of equipment for controlling temperature, humidity and air motion.

Another step in converting from pre-war to a wartime production included substitution for critical metals in air conditioning and auxiliary equipment. With basic designs unchanged, the appearance of apparatus to control temperature, humidity, and circulation of air has been altered with the substitution of noncritical metals.

Some specialized equipment has been designed to meet the particular needs of current times. The blackout plant, manufacture of concentrated foods, and other new developments have created problems that are solved by new equipment that is actually a modification of many existing designs adapted to the new requirements.

Table 1—Peace and War Uses of Heating and Air Conditioning Equipment

Equipment	Peacetime Uses	War Uses
Room coolers	Offices Homes Guest rooms	Testing laboratories Photo development Trailers Plotting rooms
Self-contained air conditioners	Stores Beauty parlors Restaurants	Airport control towers Industrial laboratories Army hospital operating rooms
Room ventilators	Offices Stores Factories	Field telephone exchanges Military film storage Instrument repair shops
Air conditioning systems	Stores Factories Office buildings	Precision instrument plants Airplane engine factories Ammunition production
Centrifugal refrigerating machines	Stores Theaters Office buildings	Synthetic rubber plants Wind tunnels Blast furnaces
Refrigeration machines (Small and medium size)	Meat markets Food storage Water cooling	Altitude test laboratories Food storage on ships Underground bombproof shelters
Cold diffusers	Dairies Meat packing Beverage plants	Photo film vaults Food preservation for Army Rubber storage
Unit heaters	Stores Garages Factories	Hangars Airplane repair shops Ballistic ranges

The end uses of apparatus controlling temperature, relative humidity, and motion of air fall into one of the five classes of application: Army, Navy, Maritime Commission, lend-lease and war industries. Typical applications in these fields, the reason the equipment is needed, and a brief description of the peacetime use of the equipment follow:

Army Installations

Administration Building—Due to the strenuousness of work, accuracy required, and a 24 hr day schedule, Army administration buildings are air conditioned either in their entirety or in specific rooms. The emphasis in air conditioning is on efficiency and workable conditions and not on comfort. Extreme climates to which some of the camps are subjected further emphasizes the need of conditioned air in the offices. Those of blackout construction are air conditioned to make the working conditions endurable.

Tabulating rooms are air conditioned to keep the machines operating efficiently, and to keep paper from sticking or becoming difficult to handle.

Drafting rooms and offices, both private and general, are air conditioned to assure efficiency of the workers.

The equipment used is similar to that supplying conditioned air in offices for civilians before war was declared.

Airplane Repair Buildings—Airplane repair buildings are, in the main, heated only, using temperature control in cold weather to maintain endurable working conditions. Unit heaters supply warmed air to the space used for airplane repair work.

The equipment is similar to that used in the past to warm hangars of commercial airlines.

AIIA Building, Trailers and Portable Houses—In armament instrument, inspection and adjustment buildings, trailers and portable houses, the air temperature and humidity are controlled and the air is cleaned. These precautions are necessary to maintain the precision of instruments that must not fail. Moisture from hands may cause corrosion; dust particles cause erosion; temperature variations cause inaccurate calibration. To guard against these hazards, the air is conditioned to prevent excessive perspiration of hands, cleaned to remove dust, and

held at constant temperatures to eliminate expansion and contraction of metals during inspection and adjustment.

The equipment for air conditioning this type of precision work is the same as that used to serve the corner drug store, beauty parlor, or general office. The self-contained unit or unitary conditioners and reciprocating refrigerating machines have thus been converted in application. They are now helping to keep the instruments of the armed forces the most reliable and accurate obtainable.

Armament Fire Control Supply and Repair Buildings—Air conditioning is required in the armament fire control supply and repair buildings to eliminate dusts that are hazardous to precision instruments. In summer the air is dehumidified and cleaned to protect delicate mechanisms from moisture of workmen's hands and from condensation of air vapor. In the winter the air is heated, humidified, and cleaned for efficient working conditions.

The apparatus is the same as that used in stores, small theaters, and general offices. It may be self-contained equipment or unitary conditioners with reciprocating refrigerating units supplying the cooling effect for removing excess heat and moisture from the air.

Armories—Armories in localities where heating is required are being warmed by unit heaters.

Ballistic Ranges — Warming various rooms, such as the small arms firing house, artillery repair buildings, labor buildings, and ballistic ranges is accomplished by unit heaters.

Barracks—To obtain an efficient, compact heating system for barracks, unit heaters are installed in many localities.

Blood Banks—Storage of blood for ready use is an actuality that is lessening the casualties of World War II. Refrigeration holds the temperatures required, makes possible the storage of whole blood, powdered blood, or plasma for transfusions as needed.

The equipment used is not unlike that of refrigerators in retail stores and restaurants equipped with reciprocating refrigerating machines.

Bomb Sight Storage Buildings—Usually consisting of a repair room and a storage room, the bomb sight storage buildings require air conditioning to eliminate moisture from collecting to cause corrosion and dust to cause erosion. Temperatures are held constant to prevent contraction and expansion of metals that might ruin the accuracy of the instrument. Particularly important is air conditioning for store rooms of bomb sights using dry air to prevent weather changes from causing condensation of moisture on metal parts.

The equipment is similar to that supplied in peacetime for air conditioning when making precision instruments.

Celestial Navigation Trainer Buildings—The exactness with which instruments in celestial navigation trainer buildings must respond requires close temperature control within the tower. Variations of two or three degrees may produce false readings. Dust particles can cause the controls to be inaccurate or fail to operate.

The equipment used is an adaptation of that which has provided year round air conditioning in public buildings during peacetime.

Clothing Storage—Recognizing that a service man may be stationed in the tropics, but when on duty be flying in altitudes that make the weather around him similar to that of polar regions, the problem of adequate and proper clothing becomes evident. To keep the clothing available and maintain it in the best conditions, storage rooms are used at the bases. Here, fur lined coats for pilots are maintained in the best of conditions with low temperature air conditioning. Many of the storage rooms are used for housing fur clothing.

The equipment used is the same as that employed in peacetime to provide low temperature air conditioning for summer storage of fur coats.

Commissary Buildings—Maintaining large storage houses for perishable supplies at Army camps requires low temperature air conditioning to keep the products in the best of condition. Differing from the mess hall refrigeration, installations in commissary buildings have larger cooling capacity.

The equipment used is similar to that which has long served the meat packer and similar wholesale food producers.

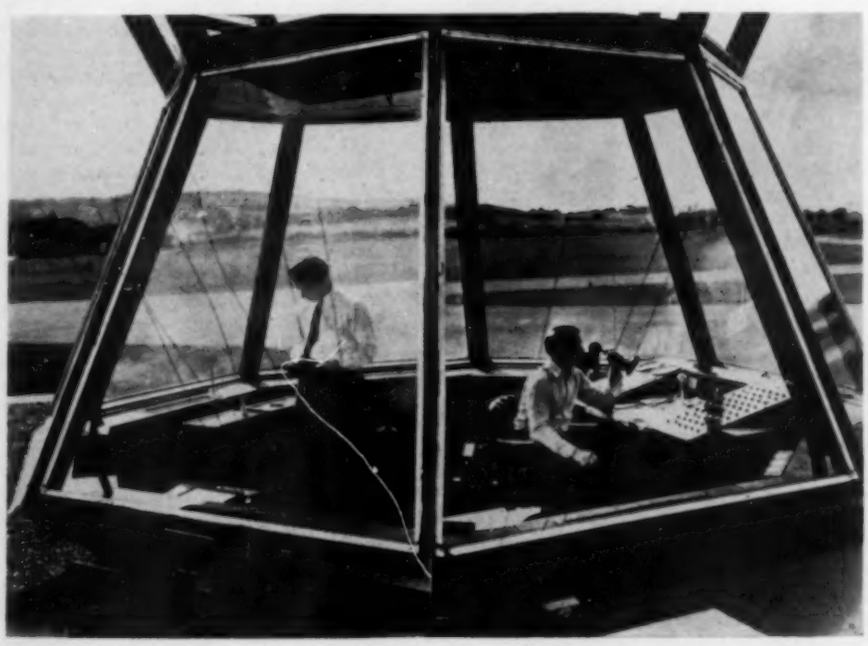
Control Towers—On the roof of an air depot or field building, or as a free standing unit, control towers are exposed to the extremes of outdoor weather. The sides, constructed of glass for vision in all directions and shaped to prevent reflections, accomplish this purpose but add greatly to the heat absorbing capacity of the room. To prevent indoor weather conditions from reducing efficiency, air becoming unbearable in warm weather, control towers are air conditioned. In summer the air is cooled and dehumidified. In winter the air is heated. At all times the air is cleaned and circulated at a uniform velocity.

Due to the requirements that all sides be free from obstructions to vision, the air conditioning unit is placed outside of the control room, below the floor level. In free standing tower installations the unit is swung in a saddle under the floor and supported from the tower frame.

The equipment used for control tower air conditioning is the self-contained type that serves small stores and tearooms in peacetime.

Depot Supply Buildings—Usually limited to the storage of fur clothing for aviator garments, equipment in depot supply building No. 1 is for low temperature air conditioning. Two rooms are served; one the "shock room" held at 0 F; the other, the "storage room," is held at 35 F. Relative humidity is not controlled as temperature is the predominating factor in preserving the furs. The low temperature in the shock room kills moth larvae, thereby eliminating a danger of furs being ruined. Many installations of low temperature air conditioning for fur storage are serving in Army bases throughout the country.

As stated under "clothing storage" the equipment is similar to that which serves the storage spaces for women's fur coats during warm weather.



Air field control towers are air conditioned to eliminate the intensive heat from the sun in order that instruments will respond correctly and workers can stay alert

Testing laboratories and factories must use air conditioning, as constant temperatures and humidities often are essential

Engine Test Building—Engine test buildings at air depots house cells where engines are tested after repairs have been made. Air conditioning, refrigeration, and heating are used in several applications in engine test buildings. These include cooling and heating air for engine carburetors, cooling oil, cooling the liquid in liquid cooled engines, and general heating and ventilating of the buildings.

Cooling and heating the air for engine carburetors consists of a system supplying general test cells. The apparatus provides temperature control only, as relative humidity of the air is not of prime importance in the carburetor tests.

Cooling oil and the liquid, which is usually anti-freeze, for liquid engines, are effectively accomplished by evaporative condensers.

General heating and ventilating is provided with various types of air conditioning and heating units, the type depending upon the geographical location of the building.

Equipment Repair Buildings—Used to repair such equipment as cameras, instruments, parachutes, the buildings use air conditioning to remove dust from the air, protect parts of camera lens and gyro parts from excessive humidity, provide effective working conditions in summer and winter, and dry parachutes to prevent deterioration from moisture.

The apparatus used to condition the air is similar to that serving commercial buildings during peacetime.

Food Storage—In many installations low temperature air conditioning is used in large food storage buildings. Meats, dairy products, fruits, and vegetables held at low temperature are kept in good condition to make the American Army the best fed in the world.

The equipment used in the installation is the same as that supplying low temperature air conditioning for products for civilians.

Fur Storage Rooms—Sometimes located in separate buildings and at others being a room in a depot supply building No. 1, fur storage requires low temperature air conditioning as given under the subject of "depot supply buildings."

Hangars—Hangars at flying fields, air depots, and other Army bases are warmed by unit heaters during cold weather. Temperature control during winter is usually all that is required in the space housing the planes. The unit heaters are the same as those serving public garages or commercial airline hangars in peacetime.

Hospitals—Recognized as a needed tool in various hospital rooms, air conditioning is used extensively in Army hospitals. Operating rooms are held at constant temperature and humidity to enhance the efficiency of the Medical Corps in performing operations. Preventing oppressive hot weather from entering the room, the doctor is not handicapped by excessive perspiration, nor the enervating effect of hot humid air. The patient is relieved of the physiological reaction caused by a high temperature, depressive atmosphere. In certain regions, the air conditioned operating room of Army hospitals minimizes the static spark hazard that would exist if the air were not conditioned.

X ray laboratories are equipped with refrigeration units to hold the emulsion and wash water for film development to the desired temperature for effective work.

Mess halls of hospitals are equipped with low temperature air conditioning for food preservation as described under the main heading of "mess halls."

Blood banks, recognized as important to medical care, are possible with refrigeration as described under the main heading, "blood banks."

The equipment used in Army hospital air conditioning and refrigeration is the same as that used in civilian hospitals throughout the country, the refrigeration in X ray rooms being that used by progressive photographers in peacetime.

Link Trainer Buildings—In Link trainer buildings conditioned air is needed to protect mechanism and controls of the Link trainer. Removal of dust is of primary importance. The air in the rooms is cooled and dehumidified, making possible long periods of training without impaired efficiency due to the enervating effect of a warm room.

The apparatus used is the self-contained air conditioner which maintains summer comfort in the neighborhood store or tearoom.

Mess Halls—To make possible the storage of food at camps, forts, and bases temperature must be held to preserve the products. Meat must be kept cold to prevent spoilage—moist enough to prevent hardening or "burning," and not so damp as to mold or become soft. This can be done with the greatest assurance with low temperature air conditioning equipment.

Fruits and vegetables, so necessary for a nutritious diet, are kept in good condition, with spoilage held at a minimum, by controlling the temperature and humidity of the air in the storage room.

Dairy products likewise are held at top quality in air conditioned storage rooms.

Equipment used for mess hall food storage comprises cold diffusers and reciprocating refrigerating machines, which in peacetime keep apples in good condition for favorable markets or permit candy manufacturers to operate on year 'round schedules, storing holiday candies made well in advance of the season.

Paint and Dope Spray Buildings—Ventilation is adequate when ordinary paint is used, but when lacquer or dope is sprayed, air dew point must be held at a low level. Sprayed surfaces are cooled by rapid evaporation of the solvent used in the lacquer or dope. If the cooling lowers the surface temperature to a point below the dew point of the air, moisture will condense on the surfaces and defeat the purpose of the spraying. To assure against such condensation, lacquer and dope spray rooms are air conditioned.

The equipment used is the same as that which prevents condensation of atmospheric moisture on chocolates in peacetime production, or on precision

instruments in peace and wartime production.

Parachute Drying and Storage—To assure against mildew, provide proper drying, and maintain parachutes in the best condition when in storage, definite procedures have been set up. In some of the steps, as in folding and storage rooms, air is conditioned to a low dew point, thereby eliminating danger of mildew. Drying towers are also equipped with controlled air.

The equipment is the same as that formerly used in peacetime industries requiring low dew point air.

Photographic Laboratories — Long used by companies making photographic films and papers, air conditioning has proved a need in the picture-taking industry. Keeping film free from dust, holding emulsions at specified temperatures for effective work, and protecting paper for quality printing of photographs, require the control of temperature and humidity of air and the removal of dusts from the air. Refrigeration is needed to hold the desired temperature of emulsions and water for developing pictures. Whether the laboratory is in a building or is a trailer on wheels, air conditioning and refrigeration is supplying the control so important for effective, accurate and reliable work.

The equipment of Army installations is similar to that used by commercial photographers in peacetime.

Plotting Rooms—Usually of blackout type with a 24 hr day occupancy, plotting rooms are air conditioned to make working conditions endurable. The equipment used is similar to that maintaining efficient weather in offices.

Post Exchanges—Refrigeration for post exchanges keeps products in saleable conditions, and is the same as that serving ice cream parlors and soft drink stands in peacetime.

Radio Repair Buildings—Due to the delicate parts involved, radio repair buildings are air conditioned to prevent dust particles being present to ruin precision performance. Summer dehumidification is provided to protect the parts from high humidities. Winter heating and humidifying assure indoor weather conditions most conducive to effective and accurate work in the building.

Like other central station air conditioning systems for the Army, the apparatus is similar to that formerly used in stores, office buildings, and small theaters.

Navy Installations

Many of the installations made for the U. S. Navy are similar to those used for like purposes by the Army. The list of Navy installations includes bomb sight repair and storage spaces, control towers, food storage, first aid rooms, hangars, hospitals, machine shops, mess halls, parachute storage, photographic rooms, refrigeration for foods at Navy bases, on shipboard, and foreign stations, ship stores, subsistence buildings, telephone buildings, test laboratories, and warehouses.

The equipment to provide temperature and humidity control and assure cleaned air is the same as that long used by the Navy. The increase in number of applications and adaptations of the equipment to wartime needs prove the importance of air conditioning and refrigeration to the men in the Navy.

Maritime Commission

Foods on shipboard have long been preserved with mechanical refrigeration; this is an application of low temperature control equipment which has been extended during 1942.

Lend-Lease

As in the other classifications of application of air conditioning, refrigeration, and heating, the lend-lease program has included much such equipment.

War Industries

Arranged alphabetically according to end uses the following tabulation gives evidence of the variety of war industries installing air conditioning, refrigeration, and heating in 1942.

Aircraft Plants—Centrifugal refrigerating machines are used in aircraft plants chilling water for air conditioning assembly rooms of engine manufacturers, tool rooms for propeller making, and piston ring machining rooms.

Air conditioning equipment is used in the aircraft plants for magneto coil winding rooms, manufacturing space for oil coolers, engine test rooms, plywood processing, film drying, first aid rooms, cafeteria refrigeration, and many other applications.

Airplane Equipment—Air conditioning for assembly rooms for airplane equipment, and maintenance of low temperature for tests of the equipment have been installed.

Blast Furnace Air—Continuing the extension of the application of air conditioning to blast furnaces, equipment has been installed for additional plants.

Blood Plasma—Long used in many pharmaceutical plants, air conditioning units are now supplying low temperatures for additional storage of blood plasma.

Bomber Plants—Centrifugal refrigeration for supplying chilled water for air conditioning the drafting room of a large bomber plant, and reciprocating refrigeration for drinking water, are among the 1942 applications.

Bomb Sights—Necessary for precision work, air conditioning is maintaining proper conditions of air in bombsight assembly rooms.

Chemicals—Supplying refrigeration to chill jacket water, two centrifugal machines are used by one chemical company in a process in manufacturing high explosives.

Film—Air conditioning has been used extensively in the manufacture and storage of film and photographic paper. In 1942 refrigeration was installed for processing gelatine used on x ray film in one plant.

Food Dehydration—With emphasis placed on reducing the volume but not the nutrition value of food for foreign use, food dehydration has become of major importance. Air conditioning to assure sanitation and low moisture content of the air is used in dehydration plants.

Laboratories—So diversified are the studies in laboratories that the range covered by installations of air conditioning for research cover low temperatures for radio testing, low humidity air for plastics, constant temperature rooms for map making, low temperatures for magneto tests, balance rooms for metallurgical research, testing laboratories for materials used in making explosives, chemical research, and test rooms for leather for the Army.

Meat Packing—The importance of meats for the United Nations classifies the meat packing industry as a war industry. Low temperature air conditioning is used extensively in the preparation of meat from the kill room to the storage of the finished product. In smoke houses controlled temperature and relative humidity provides superior quality. The air conditioning equipment used by the meat packer makes increased production possible.

Metals—Air conditioning for mixing and fill rooms in powder metallurgy, quenching metal parts for processing operations, shock tests for shells, and drying powder for pyrotechnics are among the applications made in 1942.

Optical Instruments—Lens grinding and polishing require close temperature and humidity control and the air must be clean. Companies making lenses for use in precision instruments, as range finders and cameras, use air conditioning.

Ordnance Plants—For drying black and smokeless powders, for controlling temperatures and humidity of air in assembly, packing and shipping rooms for drying primer casings, loaded primers and for many other applications, air conditioning equipment is used in ordnance plants.

Parachutes—Used in silk, rayon, and nylon mills, air conditioning serves many processing rooms for cloth used in canopies and for other products used for shroud cords of parachutes. Laboratories are maintained at specified air conditions for testing products for Army and Navy uses.

Pharmaceuticals—Long users of air conditioning equipment, pharmaceutical plants have extended their uses to meet war demands.

Photographic Applications — Discussed under "films" is the need for air conditioning and refrigeration in photographic work. New air conditioning applications include mobile trailer units.

Precision Instruments—Centrifugal refrigerating machines have been in-

stalled to chill water for air conditioning precision plants.

Radio Testing—Simulating operating conditions for radio testing requires control of air through a range of temperatures from 120 F to —76 F.

Rubber—The number of centrifugal refrigerating machines used in making one kind of synthetic rubber was considerably increased last year. Control of temperature and humidity in making rubber products was provided for many companies.

Tanks—Water for air conditioning the manufacturing space making diesel engines for tanks is chilled by centrifugal refrigerating machines in one large plant. Heating the building of another company making tanks, and another making gears and clutches for tanks is provided by unit heaters. Cooling of quench oil for tank tread pins is obtained with evaporative condensers.

Test Rooms—Rooms used for testing products for war are air conditioned to remove the weather variable. Gages, calipers, gun turrets, rifles, and other equipment are tested in air held at specified conditions.

TESTING FOR LEAKS OF REFRIGERANTS

THE EDITOR—

Concerning methods of testing for leaks of methyl chloride, sulfur dioxide, and "Freon" refrigerants, halide leak detector torches or lamps should not be employed under any circumstances for locating leaks of any combustible gases used as refrigerants, such as ethyl or methyl chloride, commonly referred to as halogenated or chlorinated hydrocarbon refrigerants. Such torches are designed for detecting leaks of "Freon-12," "Freon-21," "Freon-113," "Freon-114," and "Carrene-1."

We believe it to be extremely unwise to attempt to locate a leak of methyl chloride with a halide leak detector torch for the simple reason that 8.1 to 17.2 per cent by volume of methyl chloride vapor in air will be in the explosive range. The fact must be recognized that even a small amount of methyl chloride vapor may be concentrated on the floor or in a confined space around the leak which may produce an explosive mixture even though the small amount of refrigerant when evenly distributed to all parts of the room may not produce an explosive mixture. Thus, methyl chloride and all flammable and combustible chlorinated refrigerants should be considered a fire hazard regardless of the concentration required or the amount of refrigerant permitted to escape from the system.

The following is quoted in part from an instruction sheet published by the Linde Air Products Co., which clearly covers the subject of use of such detectors:

It must be pointed out that certain halide gases used as refrigerants—such as ethyl and methyl chloride—are combustible. Insurance and safety rules warn against searching for leaks of a combustible gas with any flame. *Therefore, under no circumstances should any flame leak detector be employed for locating leaks of any combustible gas.*

The following is quoted from a paper prepared by the writer and presented before the Refrigeration Service Engineers Society in January, 1941:

Leak detector lamps of the type now on the market *should not* be used for locating leaks of flammable or combustible gases used as refrigerants.

As to the proper method of detecting leaks of methyl chloride,

"OPEN FOR DISCUSSION"

the following is quoted from literature published by E. I. du Pont de Nemours & Co., Electrochemicals Department (formerly R. & H. Chemicals Department).

Leak Detection

Soap Water Method

Leaks of methyl chloride are best detected by placing the unit under refrigerant, air, or nitrogen pressure and applying soap solution to suspected points. During freezing weather glycerine may be used. A leak is shown by the appearance of bubbles. Small units may be immersed in a tank of water. Difficult leaks may be better located when the unit is under air or nitrogen pressure rather than refrigerant pressure as pressures can be built up to the maximum allowable for the unit and escaping tendencies of air and nitrogen are greater.

Carbon dioxide may also be used in testing for leaks, but under no circumstances should oxygen be used. Explosive reactions may take place between oxygen and oil. When testing with air, nitrogen, or carbon dioxide, the machine should not, of course, contain its refrigerant charge. Vapors of methyl chloride as well as liquid refrigerant should be absent if air pressure is to be applied. Gases used for leak testing should be dry.

Halide Torch

Because of the possibility of explosion of higher concentrations of methyl chloride-air mixtures by the open flame, use of the halide torch is not recommended for detecting methyl chloride leaks. While it is true that adequate ventilation of the space being tested should eliminate the possibility of having the minimum explosive mixture of 8.1 per cent by volume methyl chloride in air, nevertheless it is felt that the safest policy is not to use this test method.

A modification of the method that can be used on methyl chloride machines not yet charged with refrigerant is to introduce a little "Freon-12," which is nonflammable, into the machine and then test with the halide lamp. The pressure can be built up with air, carbon dioxide, or nitrogen after the "Freon-12" has been charged. A few ounces of "Freon-12" for small machines—more in proportion for larger—will suffice.

Oil Spots

Oil spots often enable detection and location of leaks in refrigerating machines as methyl chloride carries more or less oil throughout all parts of the system.

Pressure Measurement

If time allows, leaks may be detected but not located by allowing the unit to stand for at least one-half day under air, nitrogen, or carbon dioxide pressure and noting pressure readings. If the temperature of the system does not change appreciably, even relatively small leaks may be detected by this method. Pressure readings can be taken while making soap water tests on joints. Similarly, vacuum gage readings may be observed after a vacuum drying operation (see Air Conditioning Service Engineer Outlines Method for Leak Testing, by Floyd M. Mayse, Heating, Piping & Air Conditioning, February, 1940, pp. 114-116.)

Halide leak detector torches cannot be used for detecting leaks of sulfur dioxide for the reason that such a gas will not form a volatile copper halide to produce a flame color change, which is the principle of operation of such a torch. Leaks of sulfur dioxide, aside from odor, are detected and located by ammonium sulfite resulting from exposure of 28 per cent ammonia in water in the presence of sulfur dioxide.—R. J. THOMPSON, refrigeration engineer, Kinetic Chemicals, Inc.

WHERE TO USE ELECTRIC HEATING IN WARTIME

Lee P. Hynes Tells How to Determine If Electricity Is Logical for Auxiliary Heating

SUMMARY—Mr. Hynes, president and chief engineer of the Hynes Electric Heating Co., and member of HPAC's board of consulting & contributing editors, briefly reviews here the uses for which electric heating should and should not be given consideration in wartime. . . . On one job, heat is necessary in a pressroom; the electric heaters are interlocked with the press motors so that they can be used only when the motors are not running. In this way, the heaters do not add any power demand to the plant system

DUE TO the fuel shortage and the difficulties in getting additional plant equipment, many people are asking about electric heating as an auxiliary. In considering this use, the following basic facts should be kept clearly in mind:

1) The source of electric power is principally fuel, and existing power plants are being called on for heavy additional loads for manufacturing purposes. Consequently, no great amount of power is available for general heating purposes.

2) Home owners should dismiss the idea of auxiliary electric heating. Heaters are not now available in the market, and even if they were, power supply lines for homes are not adequate for heating service.

3) The only proper field for electric heating at present is for carefully selected locations in large industrial plants and government projects, where sufficient power supply is available and where the heating load can be fitted into the power schedule without serious increase of the maximum demand.

Logical Uses of Electric Heat

A careful engineering analysis is necessary in determining where electric heating can be properly used. Examples of places where electric heating can be logically used include:

a) For heat treating of materials where high temperatures, close regulation, or freedom from combustion are necessary for maintaining the proper quality of product.

b) For process work of moderate size where steam temperatures are inadequate or steam is not readily available. Also, where condensate would be difficult to drain, as in some types of machines.

c) For process work which can be done automatically at night or during week-end periods when the operation of steam boilers would require overtime for engineers and firemen and waste of fuel to keep up steam on large boilers for some relatively small but essential use.

d) For heating rooms, small buildings, or process work at isolated spots where the use of steam would necessitate heavy expense in running long steam lines and considerable cost of supervision and maintenance. Guardhouses, pump stations, valve pits, and automatic substations are examples.

e) For temporary heating of offices and small buildings during construction or as an auxiliary when steam is not available at all times.

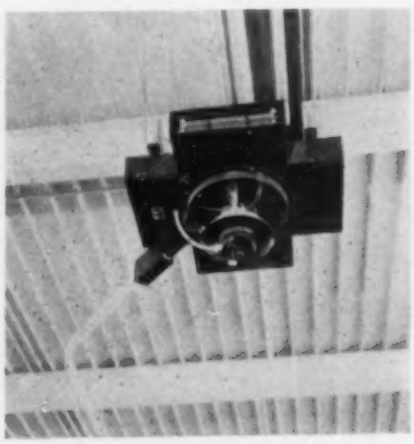
f) For heating jobs where steam is not available and local fuel combustion would introduce fire or explosion hazards. Examples are ammunition storage vaults, laboratory rooms, and chemical process work.

g) For heating oils and other fluids in circulation, for process work, or for heat transfer equipment.

h) For melting ice and for prevention of freezing at dams, surge tanks, pipe lines, valves, pumps, etc.

i) For electric hot water or steam boilers, for remote locations or for standby use during night or other offpeak periods.

Electric unit heater mounted on the ceiling in an industrial plant



In considering the logical use of electric heat, it is necessary first to determine whether any other form of fuel can be used satisfactorily. There are some processes where electricity is the only practical or safe method; many examples are found in the chemical and metallurgic fields. In cases of this kind it may be logical to install additional electric power lines and to increase the overall plant demand for power in order to meet the added electric load.

Heaters and Motors Interlocked

In those cases where other forms of heating might be used but where electricity would be advantageous for convenience or to reduce supervision, the controlling factor is usually whether the proposed heating load can be added without increasing the plant power demand. As an example, a large printing plant had presses on the fourth floor and when the plant was in operation the motor load in this room was 100 hp. While the plant was in operation the heating boilers were also in operation. During shutdown periods when the presses were not running the general plant did not need heating but this fourth floor room had to be kept reasonably warm so that the presses could be started up promptly in the morning without having trouble in handling the paper through the rolls.

Careful study showed that electric heaters should be installed in this room and interlocked so that they could only be used when the press motors were not running. In this way the installed power lines could take care of both the normal motor load and the standby heating load because they occurred at different periods of time. Under this condition the electric heating did not add any power demand to the plant system. The installation was, therefore, made and operated economically.

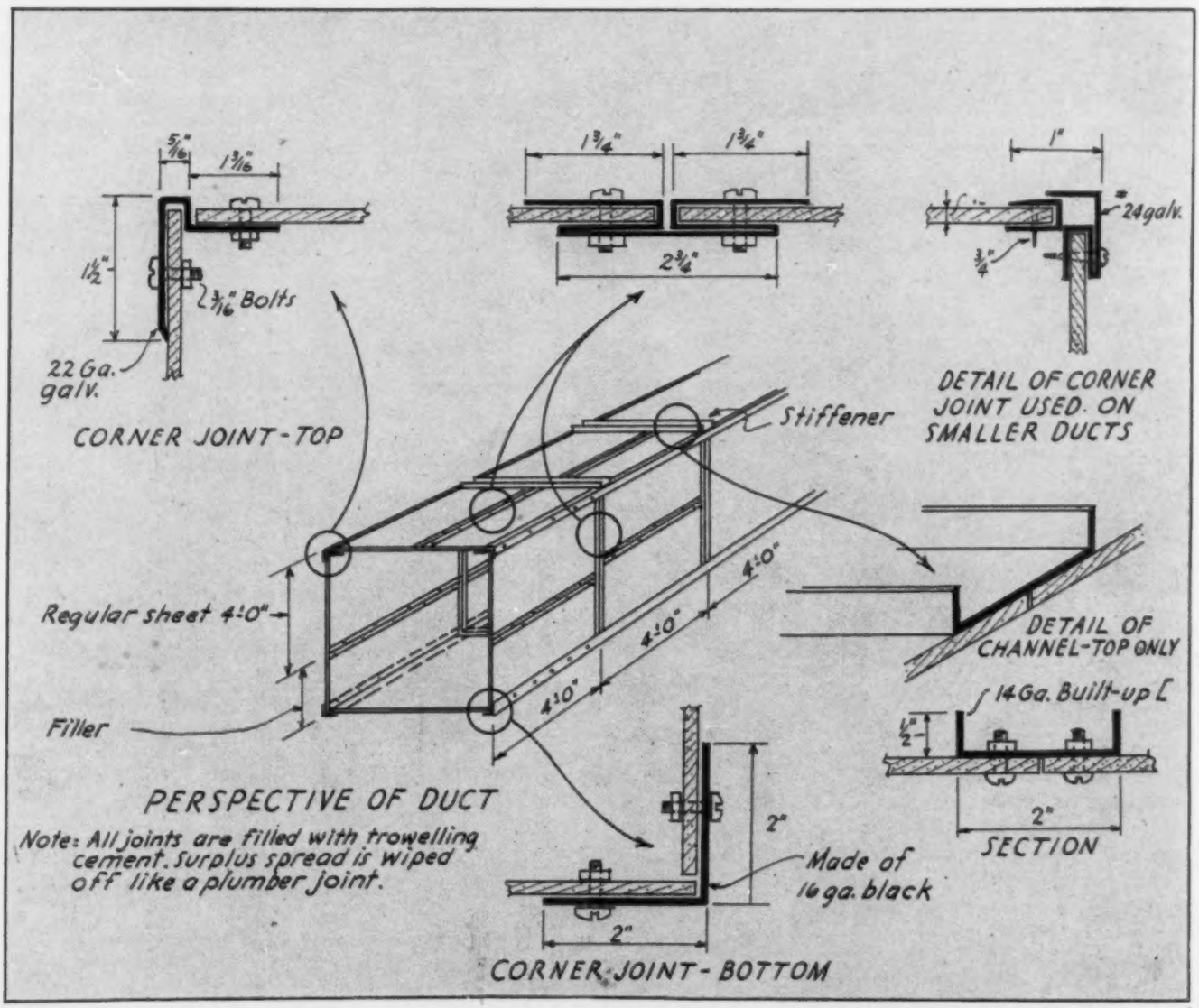
ALTERNATE MATERIAL for DUCT CONSTRUCTION

SUMMARY—Mr. Narowetz, of the Narowetz Heating & Ventilating Co., has had experience in recent months in the fabrication of more than a million square feet of nonmetallic sheets for duct construction. He gives here his practical comments on the use of such materials as alternates or substitutes for sheet metal, pointing out the factors which must be considered in choosing a material. . . . The vital importance of fire safe construction is particularly stressed

Louis L. Narowetz, Jr., Gives Contractor Viewpoint on Nonmetallic Sheet Materials, Stresses Great Importance of Fire Safety

A PRODUCT we have used to good advantage for ductwork is an asbestos fiber mixed with special cements and made into sheets of various thickness under hydraulic pressure. For ordinary ducts, a thickness of 3/16 in. has been found to be practical, since it is rigid, weighs less than 2½ lb per sq ft and withstands the general run of job abuse.

These sheets are usually 48 in. wide and 96 in. long; for duct sizes larger than 30 in., transverse joints are best limited to increments of 4 ft in sections, using transverse joining strips and corner joining cleats of No. 24 ga metal. This type of assembly has fire underwriters' approval, which—in spite of *any* expediency—is a moral responsibility to be assumed by those who undertake the design and specification of ventilating systems serving



areas where people are employed. There have been instances where workmen have joined asbestos cement sheets at the corners with wood cleats to form a duct or chamber, securing the cleats with screws. It should be recognized that a building is as strong as its weakest link and construction of this kind, permitted during this emergency, may always be a hazard and a violation of fire ordinances.

During the past several months I have been privileged to supervise one of the largest ventilating and blast heating jobs ever contemplated using asbestos cement sheets for duct systems, and have had the benefit of experience in tooling up a field shop to fabricate more than a million square feet of this type of sheet.

Relative Cost of Ducts

Actual cost of this type of material for the raw product is more than that of the galvanized metal sheets normally used, as—because of the limited sizes of nonmetallic sheets available — allowances for waste are more and breakage adds up to a figure possibly double that used for trim in fabricating metal ducts. The labor involved in fabrication is slightly more than for metal. I find that ducts of sizes smaller than 18 in. in any dimension are apt to cost twice as much as metal, and larger ducts 50 per cent more than sheet metal ductwork. Where asbestos cement sheets are used as a lining to form chambers or tunnels, the cost is much the same as for metal.

Apparatus Casings

For apparatus casings, especially where insulating requirements are specified, a good substitute or alternate for metal comprises asbestos fiber sheets with the outside slabs protected by 3/16 in. sheets, the space between being made up of laminated corrugations built up to various thicknesses from ½ to 2 in., depending upon the coefficient of insulation desired. When properly fitted in place, this construction insures permanence as well as compliance with fire ordinances. Ordinary drills and saws are employed in assembly, and metal joining strips or angles are used, with cements especially prepared by the manufacturer to butter the edges of sheets while erecting — this forms a seal so that the casing is practically airtight. This finished casing is durable, neat in appearance, and takes a good paint job. It also compares favorably in cost with metal casings plus insulation. Sheet metal workers readily adapt their skill to the handling of this material and as a substitute it is within their labor jurisdiction.

There are, of course, other materials being sponsored for ductwork. In selecting them, care and consideration should be given to their fire resistant qualities, moisture absorption, weight, and surface friction. In my opinion, any material which is combustible or readily absorbs moisture will not pass fire underwriters' tests or city codes for sanitary requirements.

Advantages of Sheet Metal

Some favorable aspects of sheet metal, when used to convey air, are its smooth surface, sanitation, approved status by fire underwriters, and the amount of surface it can cover per cubic foot with its lesser bulk; thereby, shipping space of this raw material is reduced to a minimum. Also, custom and usage have developed men skilled in the art of fabrication and erection of sheet metal, and adapting them to the use of substitutes naturally is more costly in the initial stages of working a new material.

There is another strong point in favor of sheet metal with which it is difficult to cope when using alternates or substitutes—that is, the making of transition pieces when changing from one duct shape to another. There are many instances where unforeseen interference encountered in the field—structural requirements, piping, etc.—must be accommodated. It has always been practical to measure and fabricate such pieces in the field, and the ductility of sheet metal is a great advantage in such instances.

MATERIALS CONSERVATION PLAN INCLUDES SALVAGE AND SCRAP PREVENTION

An extra 5,000,000 lb of metal, rubber, and other war needed materials were salvaged within three months as a result of an intensive scrap drive by all divisions of the Westinghouse Electric and Mfg. Co. This was in addition to routine collections made regularly in all company divisions.

Nothing was spared in the company's war on scrap. Included were many old electric motors which were beyond repair. One division turned in 300,000 lb of old metal parts; by rummaging through office desks, hundreds of pounds of metal paper weights and tons of paper were collected. An abandoned transformer tank at the high voltage laboratory produced 10 tons of steel and five more of copper. Five miles of an old telephone line was ripped up to get eight tons of lead and another ton of copper.

The scrap drive actually is the second part of a two part plan of material conservation. The first job is to prevent scrap by making fullest possible use of the original materials. Typical of this is the turning in of old welding rod stubs before new ones are given out. This procedure resulted from the observation that welding electrodes or coated steel rods were being discarded while still long enough to use. Consequently, a supervisor in the motor division devised a box which contained new rods and a small compartment for the used stubs. The slot in this compartment is about 2½ in. long, which limits the size of the stubs that can be inserted.

To get a new supply of rods, the welding operator must turn in a stub for each rod. This system has reduced scrap loss in welding rods by 30 per cent and it means a saving not only in steel rods but in such vital materials as magnesium, which go into the coating of rods.

The conservation drive will continue as long as the war lasts. It was started with an office cleanup week, confiscating rubber ink wells, paper weights, enough low grade metal gadgets to build eight Army tanks and a lot of other things. Several dilapidated freight cars have gone the way of the other scrapped materials.

Practical Application of Recent Developments in Theory to Air Conditioning Design Problems

William Goodman Assembles Basic Facts and Tells Their Significance in Simple Language

SUMMARY — Developments in the theory of air conditioning in recent years have made it possible to design practical air conditioning systems on a more rational basis than has hitherto been the case. Rational methods of design result in more nearly correct and suitably sized air conditioning systems. An incidental, but today equally important, result is the fact that rationally designed systems may also be economical ones. For example, air volumes selected by rational methods are frequently smaller than volumes selected by empirical methods. In these critical days when the conservation of raw materials is so vitally necessary, anything which contributes to a reduction in the size of equipment is of especial value. When the method of operation of an air conditioning system is changed, due to wartime conditions, best results are achieved if fundamentals are not disregarded. . . . The basic facts on the theory of air conditioning have been scattered through many different papers. In the article of which this is the second part, these facts have been gathered together and presented in a logical order which clearly shows the relationship between the various elements directly applicable to the design of air conditioning systems. No mathematical treatment is attempted. Instead, an attempt has been made to present in simple language a clear picture of the physical action taking place in the various component parts of air conditioning systems. . . . Mr. Goodman is consulting engineer, the Trane Co., and a member of HPAC's board of consulting & contributing editors

THE PSYCHROMETRIC chart is an invaluable aid in the design of air conditioning systems. More than this, it provides a simple and rapid means of understanding many otherwise complex phenomena in air conditioning. Many problems that are today simple and easy to visualize with the aid of the chart would require considerable work to visualize and solve without the aid of the chart.

The "condition curve" on the psychrometric chart was described last month; discussion of its uses is continued in the following paragraphs.

Relation of Condition Curve and Sensible Heat Percentage Line

If chilled air is to be supplied in the condition in which it leaves the cooling coil, it is evident that the point selected on the condition curve must also lie on the percentage line if the desired condition is to be maintained in the conditioned space. In Fig. 7 a condition curve is shown together with the sensible heat percentage line. It is quite apparent from this illustration that in order to maintain the air in a room in condition *1*, the air leaving the cooling coil must be in the condition represented by point *4*. If the air is not to be treated after it leaves the cooling coil, the air supply must be in a state which lies at the *intersection of the condition curve and the sensible heat percentage line.* This is always true regardless of whether the air supply is conditioned by means of an air washer or by means of a coil. No matter how the conditioning of the air is accomplished, if there is to be no subsequent treatment of the air, the air supply must be in a condition which is represented by a point that lies at the intersection of the condition curve and the sensible heat percentage line.

Fig. 7—Diagrammatic illustration on psychrometric chart of complete air conditioning cycle with dehumidifying coil

Inasmuch as coils consist of a definite number of rows, it is obvious that the point representing the chilled air supply cannot always lie on the percentage line. For example, the point representing the condition of the air leaving a six-row coil might lie on the condition curve above point *4* of Fig. 7, whereas the point representing the condition of the air leaving an eight-row coil might lie below point *4*. In such a case, the eight-row coil should, of course, be selected. Inasmuch as the air will be cooled and dehumidified to a slightly lower condition than is needed, a small factor of safety will be provided. This is analogous to the commonly used method of selecting blast coils for heating. A blast coil that will provide air at the exact temperature needed according to computations can rarely be obtained; instead, a blast coil is selected which will supply air at a slightly higher temperature than the temperature really required. In this way, a slight factor of safety is provided for heating.

In cooling, the point selected for the condition of the chilled air sup-

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ply should always lie on the condition curve *below* the percentage line. As stated previously, air in any condition along the percentage line can be obtained if additional equipment is provided for treating air after it leaves the cooling coils. For example, air can be reheated to, say, point *5* of Fig. 7. The air could first be cooled to a point on the condition curve which lies on the same horizontal line as point *5*, and then be reheated to point *5*. However, regardless of whether the air is supplied in the condition represented by point *4* or point *5*, the resulting temperature and humidity in the conditioned room will be represented by point *1*. Hence, in this case, there is little advantage in reheating the air.

One of the advantages of colder air is that a smaller quantity of air need be supplied. This means smaller ductwork and a smaller fan with reductions in both first and operating cost. Until recent years, the principal objection to supplying cold air has been the difficulty of introducing such air into rooms without drafts. This difficulty has been largely eliminated by the effective air inlet devices of both the wall and ceiling types which are now available. With modern air supply devices properly selected and placed, there need be no fear of drafts. Drafts should be prevented not by controlling the temperature of the air supplied to the room, but by the method of introducing the air into the room.

Classical Explanation of Dehumidifying and Cooling

For many years textbooks have shown the cooling and dehumidifying of air as occurring as illustrated in Fig. 8. If air in the initial state represented by point *1* was brought into contact with either cold water or a cold surface, the air was assumed to cool from point *1* to point *2* at a constant dew point temperature. After the air had become saturated at point *2*, the rest of the cooling and dehumidifying of the air was assumed to take place along the saturation curve to the final condition represented by a point such as *3*. Such a cooling cycle is impossible to obtain in any actual coil or air washer.

Cooling at a constant dew point temperature followed by cooling along the saturation curve represents a theoretical limiting case that can never be obtained with actual conditioning equipment. If the temperature of the cold surface is lower than the initial dew point temperature of the air, cooling along a line of constant dew point temperature can take place only if

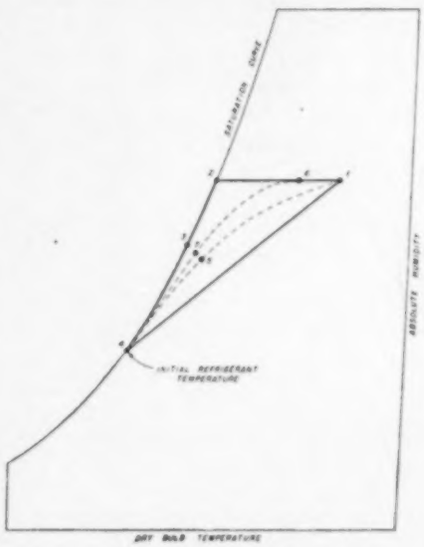


Fig. 8 — Limiting triangle within which all points representing condition of air leaving dehumidifying coils must fall

the value of the coefficient of heat transfer through the saturated air film is infinitely large. In this case, the temperature of the cold metal will always be the same as the dry bulb temperature of the air. Consequently, dehumidification cannot take place until the air has been cooled to its dew point temperature; that is, until the air has become saturated. After this, because the air is saturated, further cooling of the air will take place along the saturation curve. Inasmuch as the film coefficient of air is usually small in value, it is obvious that cooling along a line of constant dew point temperature and then along the saturation curve can never occur in actual equipment.

Another limiting case is obtained when the value of the coefficient of heat transfer through the refrigerant film on the inside of the tubes becomes infinitely large. In this case, the surface of the metal would be equal to the temperature of the refrigerant. For a direct expansion coil in which the temperature of the boiling refrigerant is theoretically nearly constant, the entire coil would be at a constant temperature equal to the temperature of the boiling refrigerant. In this case, the saturated surface film of air would also be at the same temperature as the refrigerant and mixing of the air entering the coil with the air in the surface film would take place along the straight line *1-4* of Fig. 8. In other words, as the air passed over the surface, the air would be cooled along mixing line *1-4* from point *1* to some point slightly below *1*. As the air entered the next row, it would still be cooled along the mixing line between points *1* and *4*. Consequently, mixing in the subsequent rows would always take place along the same straight line *1-4*. In an actual cooling coil, such cooling cannot, of course, take place because the coefficient of heat transfer through the refrigerant film is always finite. Instead, the actual cooling of the air must take place along a condition curve which appears somewhat like the dotted curves of Fig. 8.

The greater the value of the heat transfer coefficient through the air film, the closer the dotted condition curve of Fig. 8 will tend to approach the cooling cycle *1-2-3*. On the other hand, the greater the value of the heat transfer coefficient through the refrigerant film, the closer the dotted condition curve will tend to approach the straight line *1-4*. The actual location the condition curve will assume depends, of course, upon the relative values of the two heat transfer coefficients.

Fig. 8 illustrates the very important fact that *the triangle formed by points 1, 2, and 4 encloses all the final points to which the air can be cooled and dehumidified by any kind of an air conditioning apparatus.* This is true regardless of whether the conditioning equipment is a cooling coil or an air washer. With finite values for the heat transfer coefficient through the two surface films, the condition curve for air which is being cooled and dehumidified will always lie inside the triangle *1-2-4*. All of the condition curves that can be obtained for different values of the

heat transfer coefficients will fall within the limiting triangle *1-2-4*.

This limiting triangle is of great practical significance because it shows at once whether it is possible by means of any cooling and dehumidifying apparatus to cool air to some given final condition. Frequently, the final condition specified for the air leaving a cooling coil or air washer will be represented by a point which falls outside of this limiting triangle. Air in a condition outside of the limiting triangle cannot be obtained from any type of cooling and dehumidifying equipment alone. Air in a condition represented by a point outside of the triangle can be obtained only at the expense of additional equipment, such as reheating or bypassing.

Conditions in Room Depend Upon Condition of Air Leaving Coil

Frequently, the quantity of air to be supplied is determined not from considerations of the quantity needed to absorb the heat and moisture gains in the room but on the basis of ventilation requirements. If a larger quantity of air is selected than is needed to absorb the heat and moisture gains in the room, it will not be possible to cool the air to a point below the percentage line without providing a greater refrigerating capacity than is actually needed. If a large quantity of air, which has not been chilled to a point on the percentage line, is supplied, the desired dry bulb temperature in the room can probably be maintained but the relative humidity will be considerably higher than that for which the system was designed.

The cold, clammy feeling noticed in some older installations is due to the fact that extremely large volumes of air were used. As a result, the large volume of air could not be cooled to a low enough dew point temperature. At the same time, there was sometimes not a sufficiently large sensible heat gain to warm the large volume of air to a comfortable final dry bulb temperature. Consequently, such spaces were frequently cold and clammy. It has been the author's experience that where a cold, clammy feeling exists, invariably the volume of air supplied is too large rather than too small.

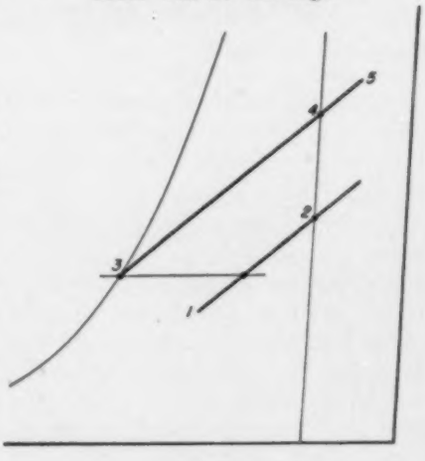
Large volumes of air supplied to a conditioned room not only frequently result in too high a relative humidity, but—what is equally important today—in a waste of materials and equipment. In other words, if a smaller volume of air had been supplied, smaller ductwork and smaller fans and motors would have been required. In addition, all electrical control equipment and wiring would have been proportionately smaller. To top all this, the selection of a smaller air quantity would result in better final conditions in the room! Therefore, in these days particularly, there is little excuse for selecting air volumes on an empirical and irrational basis simply because such a procedure has been followed for many years.

Steep Percentage Lines

In problems involving the cooling and dehumidification of air, it is desirable that the condition curve and the percentage line should intersect, as in Fig. 7. If they intersect, no reheating will be necessary. An air supply in the state represented by the point of intersection will maintain the desired condition in the room.

However, there are cases in which the percentage line will not intersect any condition curve that can be obtained with equipment that simultaneously cools and dehumidifies air, but does not reheat it. In Fig. 9, percentage line *1-2* is so steep that it cannot intersect any condition curve—the percentage line falls altogether outside of the limiting triangle previously discussed. Hence, for a percentage line such as *1-2* which falls considerably outside of the limiting triangle, the air must be reheated after first being cooled and dehumidified. In order to obtain air in a state represented by a point on the percentage line *1-2*, the air, after first being cooled and dehumidified to some point like *3* within the limiting triangle, must then be reheated to a point on the percentage line.

Fig. 9—If reheating is not provided for steep ratio lines, humidity in room will be too high



REMEMBER

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Steep percentage lines are most likely to be encountered in rooms in which people are dancing or exercising. The moisture liberated by people when exercising is more than triple the amount liberated when they are at rest. On the other hand, the sensible heat liberated by people remains practically constant regardless of the degree of activity. Because of this, the percentage line in places like ballrooms may be so steep that desirable conditions cannot be maintained without reheating the air.

Where steep percentage lines occur, reheating is usually necessary if satisfactory humidities are to be maintained. Thus, in Fig. 9, if the room air is to be maintained in the state represented by point *2*, the air supply must be in such a state that it can be represented by a point somewhere along the percentage line *1-2*. To obtain an air supply in such a state, reheating is necessary. Suppose, however, that no reheating is provided and that the air is introduced into the room in state *3*. The state of the air supply will change in the room along the percentage line *3-5* parallel to line *1-2*. If the dry bulb temperature represented by line *2-4* is to be maintained, the final state of the room air will be represented by point *4* instead of by point *2*. Even though the dry bulb temperature is the same at points *4* and *2*, the relative humidity at point *4* will be considerably higher than the given relative humidity at point *2*.

Reducing Fuel Oil Waste

HPAC DATA SHEET

THE CHART on page 729 of the December issue was prepared by O. M. Elliott and W. S. Hobbs of the Sun Oil Co. as an aid to wartime fuel oil conservation. By its use, the fuel oil wasted by inefficient furnaces operating with *clean fires* may be estimated.

The chart is of assistance in indicating the amount of fuel oil wasted for heating industrial and commercial buildings, as well as residences. Messrs. Elliott and Hobbs have also compiled the following table on cause, evidence, and correction of waste in residential heating. This table is presented here for the benefit of the many readers of HPAC who have been asked to advise their neighbors on home heating and fuel oil rationing, and for those readers who are assisting local rationing boards in an advisory capacity on the fuel rationing and heat conservation problems of home owners.

CAUSE OF WASTE	EVIDENCE OF WASTE	CORRECTION OF WASTE
THE FOLLOWING THREE ITEMS ARE CHECKED BY THE CHART		
1. Excess air for fire.	Low carbon dioxide at top of furnace firebox.	Reduce air to burner as much as possible without making smoke and soot. Match air mixing nozzles with oil atomizing nozzle for gun type burners. Check firebox size and insulation and rebuild if necessary.
2. Air leaks into furnace above firebox.	Lower carbon dioxide at furnace smoke pipe connection than at top of firebox. These air leaks may be found by going over the entire furnace with a lighted candle to find where the candle flame is sucked in.	Seal all unnecessary air leaks with suitable cement. Then recheck with lighted candle. Keep fire door tightly closed. Seal with cement all furnace doors which show evidence of air leaks.
3. Excessive temperature at furnace smoke pipe connection.	Dirty furnace heat transfer surfaces. Flue gas temperature above 500 F to 600 F at furnace smoke pipe connection between furnace and draft regulators.	Clean furnace. Have service man reduce firing rate if practical. Improve distribution of hot gases through furnace, if practical. Increase furnace heat transfer surface if possible.
THE FOLLOWING TWO ITEMS COVER ADDITIONAL FURNACE WASTES:		
1. Fuel not completely burned.	Dirty or smoky fire. Excessive soot deposits. Unburned oil vapors leaving furnace. Carbon monoxide in flue gas.	Check grade of fuel oil to determine suitability for burner. Use correct grade of oil or rebuild burner and firebox to suit grade of oil being used.
2. Excessive draft.	Draft measurements. Unsuitable draft regulating equipment.	Adjust draft regulator or install suitable draft regulator and adjust.
THE FOLLOWING THREE ITEMS COVER FUEL HEAT LOSSES BEYOND FURNACE:		
1. More fresh air than necessary entering heated rooms.	Fireplace flues left open. Cracks around windows and outside doors, and around inside doors to rooms where windows are open.	Keep fireplace flues closed. (Do not use fireplaces. They are extremely wasteful. Stoves are much to be preferred.) Install weather stripping on windows and doors and seal cracks and openings. Keep windows and doors closed except for necessary ventilation. The colder the weather the smaller the window opening required for adequate ventilation.
2. Overheating of any portion of building or house.	Hot radiators in unused rooms. Temperature higher than use of room requires.	Reduce heat to each room being heated in excess of actual requirements. This may be done by partly closing radiator valves or hot air ducts, or by partly covering radiators or hot air grills.
3. Building or house unsuitable for efficient heating.	Poor construction. Poor maintenance.	Plug air leaks with suitable material. Insulate house and install storm windows, if possible.

Unique System Under Clock Control Used in Research on Pasture Grass

By Terry Mitchell*

FOR MANY years, experiment stations at various land grant colleges have been working out improved methods of growing farm products. Pasture grasses have, however, tended to be neglected, as they were considered among the things which just grew naturally. Either your farm had good pastures or it didn't.

Now this has been changed. The reasons for good or bad pastures are being studied, and the same progress that has characterized other efforts toward farm improvement promises to be made. The United States Department of Agriculture has a regional pasture research laboratory at State College, Pa., which is investigating the pasture problems of the entire northeastern part of the country.

One of the interesting jobs has been to devise equipment and make daily readings showing the amount of light obtained from the sun on a square foot of ground, as the seasons vary through the years.

A unique achievement on the part of this laboratory is a special four-compartment test box in which pasture plants can be grown under weather conditions equivalent to those in any part of the civilized world. These compartments have separate temperature control for the soil boxes in which the plants are actually grown, and for the air surrounding the plants.

Each compartment is 5 ft square by 7 ft high, and is insulated with 6 in. of corkboard. The interior space is sealed against moisture flow through the walls by a lining of sheet copper painted white so as best to reflect the "sunlight." Three heavily insulated doors permit access to each compartment; the two bottom doors open into the lower part under the soil box, which stands on legs. Inside the upper door is a thin metal one provided with a window. This inner door keeps the conditioned air in the compartment from rushing out when the main door is opened, and also permits inspection of the plants without disturbing the conditions in any way.

The top of each compartment is made of three layers of plate glass and above these is a battery of 24 fluorescent lights, the tubes of which are each 4 ft long. These lights are mounted on a carriage which can be pulled forward to make them accessible.

Arrangements have also been made to run water across the top of each compartment if desired, and dyes can be added to this water to change the color and study the effectiveness of the various wave lengths of light. Separate program clocks govern the lights, making them come on at "dawn" and go off at "sunset".

All other conditions inside the boxes are under similarly accurate environmental control. The dry bulb temperature inside each compartment can be controlled within plus or minus 1 F and the relative humidity within 5 per cent; this humidity can be varied between 20 per cent and saturation. The soil boxes are really insulated baths of brine, the temperature of which is accurately controlled, and into which the jars containing the plants are lowered.

Brine is used for both heating and cooling throughout the system. Agitation of the brine inside the soil tanks is obtained by constant recirculation. Four small double pipe heat exchangers with warm brine in one part and cold brine in the other, are used for regulating brine temperature. Each compartment also has its own brine pump.

Valve positioners control the feed of steam for humidity, or the flow of hot, medium, or cold brine as needed. The cold brine temperature sometimes gets as low as —10 F. The cold brine is stored in a tank containing four or five hundred gallons, above which is mounted a cooler. This cooler is 34 pipes wide. Each of the four refrigerating units is connected to a separate group of these cooler pipes. The hot brine can be heated to 150 F by steam. The warm brine, which never gets above 70 F, is in a smaller tank at the end of the hot brine tank. All the brine mains are contained in an insulated trunk. Finned coils are placed in the air stream, and are fed with brine at exactly the temperature needed to maintain the right conditions.

Two low pressure condensing units, each of 5 hp size, are connected to the cooler. Either machine is capable of carrying the normal load while the other stands in reserve, but both are used for bringing the brine down to temperature before a test run is made. Two smaller machines are tied in to the refrigerating system, and are useful for running under very light loads. The machines go into operation in steps.

To start a test, shoots from the same plant are placed in each of the four compartments. Charts are then drawn for a week in advance, showing the conditions of light, temperature and humidity desired at various hours of the day and night. These charts are then cut out with shears on forms of sheet aluminum, which are placed in the control instruments. There is one chart for the condition of the air and another for the condition of the soil. Recording thermometers register the results obtained through the use of these control charts or forms, which are really cams. Light arms, equipped with rollers, follow the outside edges of the cams as these slowly revolve on time clocks. All the controls governed by these cams are air operated. Filters or dryers clean the air, which must all pass through a room at 34 to 36 F to eliminate excess moisture.

The circulation of conditioned air through the boxes has been arranged so that the "wind" velocity over the plants is generally only about 1 mph. Fans can, however, be installed to simulate a gale.

*Frick Co.

WHY FUEL OIL IS RATIONED AS IT IS

From a Statement by Joel Dean Director, Fuel Rationing Division Office of Price Administration

THERE HAS been much public discussion of the plan for rationing fuel oil which the Office of Price Administration adopted. Some of the comments made have been highly adverse. That criticism, from whatever source, is welcomed. Rationing is a hard job—often a complicated job. It must take care of many different types of individual needs. It must be fair. It must be done in such manner that everyone has his just share of the total supply. The OPA is charged with doing that job. All constructive criticisms and all sound suggestions help us do the job.

However, in recent discussions of the plan, many of the difficulties have been overlooked. People who honestly and conscientiously suggested that it would have been better to handle things differently failed to take account of the reasons for which the present plan was adopted.

The basic purpose of the fuel oil rationing program, like that of any other rationing program, is to make certain that everyone who needs fuel oil gets his fair and just share of the total supply. Rationing does not create shortages. It merely seeks to make certain that, under a condition of scarcity, everyone can get his share without *waiting in queues* and without finding that there is nothing left for him.

This basic purpose of fuel oil rationing can be satisfactorily accomplished only if certain other principles are recognized:

(a) Everyone should have an equal opportunity to obtain as nearly as possible the same degree of physical comfort;

(b) A person who has previously wasted fuel oil should not now benefit from such waste but should be forced to conserve;

(c) A person who has previously been an economical user of fuel oil should not be penalized by the plan—he should not be subjected to as heavy a cut as the wasteful user;

(d) Conservation of fuel oil must be encouraged. The necessity of insulation and of improving burner efficiency—the necessity of conversion, wherever possible—should be recognized, and the plan should stimulate such changes.

(e) The plan should operate in such a manner that the supply of fuel oil is sufficient to meet all minimum ration requirements. For that reason it may even be necessary to allow an extremely wasteful user less oil than the amount he would regard as his minimum need.

These objectives are generally accepted. No one would deny that any effective and successful rationing plan must go as far as it possibly can toward meeting them.

In deciding how to ration fuel oil, especially for private houses, there was a choice between two basic methods. The first method was to allow everyone a flat percentage of his use last year. The second possible method was to devise a system which would distinguish between the wasteful user and the economical user—which would guarantee that the wasteful user would be cut more than the efficient user.

The plan under which we are operating retains all of the important advantages of the percentage plan. In most cases, the ration which may be allowed is actually 66⅔ per cent of past consumption. However, the plan carefully avoids the possibility of any reward to the wasteful user or of any penalty to the efficient user. It operates in such a manner that no one can get more than the highest reasonable fuel allowance for his house. The wasteful user would be limited by this maximum allowance, even if his past consumption exceeded it. The plan also fixes a minimum, so that the very efficient user who was economical last year is not cut to the full extent. He may be cut only 15 per cent, or he may be cut 25 per cent, depending upon how effectively he conserved oil.

Under the existing plan no one could get a ration of 1400 gal for heating a house merely because he used 2100 gal last year, if 1000 gal is the most which should reasonably be used in that house. If he operated wastefully, kept windows open, did not insulate, and maintained high temperatures, he cannot benefit from that waste. On the other hand, a man who used 900 gal last year, in a well insulated house kept at a low temperature, would not be cut to 600 gal if the minimum reasonable need is greater than that.

It is true that the plan is not as simple as a straight percentage cut. In order to get the results described above, it was necessary to accept certain complexities.

Those results are obtained by using a formula to fix the maximum and the minimum rations which would be allowed to a given house. However, even that element of complexity is not as serious as it sounds. The entire plan and all operations under it are set forth in tables and work sheets. Once the floor area of a house is known, once its past year's consumption is known, the determination of the ration is almost automatic. It is merely necessary for the local rationing board to refer to tables which it has received and make simple computations.

There are many other advantages which the present plan has. It provides for adjustments which take account of differences in normal temperatures from one locality to another. Rations are corrected to avoid unfairness and hardship which might otherwise result from abnormal weather conditions in many localities last year. By differentiating between efficient and wasteful users of fuel oil, the plan picks out the group which has the greatest opportunity and incentive to conserve oil—and asks that group, in its own interest and in the public interest, to take all possible steps to conserve. At the same time, the plan recognizes that those who already operate efficiently, have done their best and that, if cut uniformly, they could do nothing but suffer.

SUMMARY—The author was until 1941 the chief engineer of a French firm engaged in air conditioning engineering, particularly with adsorbents. Although many varied problems for the French army and navy were handled and solved, most of the firm's activity after 1931 was concerned with bombproof shelters, storerooms, forts, and factories. . . . The necessity for humidity control in underground spaces was imposed by the considerable deterioration of equipment or supplies and numerous cases of pneumonia among men manning forts or servicing storerooms; dormitories in forts could not always be occupied as they were meant to be. At first, no one had any idea either of the order of magnitude of the capacities required or of the most adequate means; wall evaporation was not suspected because the walls looked dry. . . . The bulk of this discussion bears on wall evaporation. This is intentional because it has been the author's experience that this source of humidity is always underestimated, if not disregarded entirely. He stresses the importance of this factor and how to cope with it; other sources of humidity are merely mentioned because their handling is just usual air conditioning. In the January, 1942, HPAC, Mr. Ledoux stressed the importance of the wall evaporation moisture factor, and enumerated means of reducing the conditioning load. In June, adiabatic conditioning of underground storerooms was discussed in the light of a numerical example. (Operation is adiabatic when the wet bulb temperature of the inlet air is equal to the "natural temperature" of the space.)

Humidity Control in Underground Bombproof Spaces

By Edward Ledoux

SINCE ADIABATIC operation requires that there be no heat loss as the conditioned air travels down the inlet duct, the discussion in my June article implied insulation of the duct. If the heat loss is such that the temperature of the air has dropped to room temperature by the time it reaches the grille, the inlet conditions will be represented by point O' in Fig. 3, p. 365, June HPAC, and the operation will be isothermal along the humidification line $O'C$. Although the air will be admitted at a lower wet bulb temperature than the natural temperature of the spaces the humidification line will not vary with time because no heat is communicated to the walls; the heat required for vaporization is furnished by the loss from the duct which acts as a countercurrent heater. For isothermal operation, the absolute humidity curve of Fig. 2, p. 365, June HPAC, will be the same as for adiabatic operation, but plotting the relative humidity curve will show a substantial increase due to the lower dry bulb temperature which will result in the space. The relative humidity curve for isothermal operation, in the case of the numerical example under consideration, is plotted in *dotted* line on Fig. 2. The advantage of uniform temperature is offset by the increased relative humidity, and insulation of the inlet duct is preferable.

In practice, the heat loss through an uninsulated inlet duct will not be sufficient to cool the air to room temperature and a slight temperature rise will occur; no heat will however be communicated to the walls and the humidification line, such as $O''C$, will be independent of time provided the conditioning plant operates at the proper wet bulb temperature.

Intermittent Operation

If the conditioning plant is shut down and the ventilation stopped, the humidity in the spaces will rise gradually until saturation is reached again. This will be caused by diffusion of humidity evaporated laterally from the walls and by longitudinal diffusion from the high vapor pressure end to the low vapor pressure end of the spaces, the latter being the one where the inlet grille is situated. The rate of humidity variation with time *depends essentially upon the location considered;* in particular, if the location is that where the initial humidity is the average, the longitudinal diffusion will be without influence on the time curve.

Let us determine the vapor pressure variation in the space already considered, when ventilation is shut down after reaching the limit humidity through isothermal operation. The average humidity in the space is 0.005 lb per lb of dry air and, referring to Fig. 2 [p. 365, June HPAC] it will be seen that this humidity is to be found 90 ft from the inlet grille. We will consider variations at this section along a vertical line from the apex of the ceiling down to the floor. The temperature is uniform and equal to 56 F (saturated vapor pressure p at this temperature is 0.45 in. of mercury). We will assume that the initial humidity (i. e., at the moment of shutdown) is uniform laterally and equal to 0.005 lb per lb of dry air throughout the cross section (vapor pressure p_1 is 0.235 in.).

When, as in the present case, the vapor pressures are small compared to the total pressure H of the humid mixture, diffusion into still air can without great error be assimilated to equal molal diffusion at pressure $(H - p)$ and the rate of evaporation is then given by $r = -f(dD/dx)$ in which f is the coefficient of diffusion in sq ft per hr, r is the rate of evaporation in lb per hr per sq ft, D is the vapor density in lb per cu ft, and x is the distance of travel of the vapor in ft.

This expression, it will be observed, is similar in form to that of heat diffusion and it can be demonstrated that the methods used in computing temperature variations due to conduction can be applied to the determination of vapor pressure variations due to diffusion if diffusivity is replaced by the coefficient of diffusion and temperature by vapor pressure.

Fig. 1, published this month, shows the results obtained by transposition of the well known Schmidt method of graphical computation to the present numerical example; due to the arched ceiling of the space, the laminae must first be expanded [see Nessi and Nisolle: Chaleur et Industrie, vol. 1, p. 193, 1928] as in the case of heating of long cylinders; the side walls having approximately the same effect on diffusion from the floor in the plane considered, the dot and dash line is for all practical purposes an axis of symmetry and 13 ft., 0 in. is half the distance between the floor and the apex of the arch. On Fig. 1, the left hand graph is the construction diagram with expanded laminae while the right hand one, obtained by projection, is the true form of the vapor pressure curves. In the present case we have $p = 0.45$ in. and $p_1 = 0.235$ in. while the coefficient of equal molal diffusion at 56 F and 29.92 in. total pressure is 0.90 sq ft per hr according to Winkelman's figures; at pressure $(H - p) = 29.47$ in., and the coefficient is therefore

$$f = 0.90 \frac{29.92}{29.47} = 0.9138 \text{ sq ft per hr}$$

The wall evaporation at different time intervals is determined by the horizontal projection X of the initial tangents* and is given by:

$$W = f \frac{D - D_1}{X} = \frac{f}{RT} \frac{p - p_1}{X}$$

For instance, referring to Fig. 1, it will be seen that after 20.343 hr have elapsed, X is equal to 11.25 ft and the wall evaporation is:

$$W = \frac{0.9138}{1.21 \times 519} \times \frac{0.450 - 0.235}{11.25}$$

$$= 0.000028 \text{ lb per hr per sq ft}$$

When shutdown occurs after adiabatic operation, the temperature of the air is higher than in the previous case. However, since the coefficient of vapor diffusion increases only as the power 1.63 of the absolute temperature and since, due to diffusion of cold from the walls, the temperature difference decreases with time and distance from the walls, the effect of temperature can be neglected for all practical purposes in the considered case of underground spaces.

Actual Results

A theoretical discussion such as the foregoing is of great interest inasmuch as it brings forth the main controlling factors of operation and therefore not only gives an idea of what to expect but also enables the engineer to base the design of the conditioning apparatus on sound principles. However, it cannot be expected that the curves actually obtained in the field should coincide exactly with those obtained through theoretical calculations, because there are several factors which have not been and cannot be taken into account. Let us review them rapidly.

It will be seen that the previous calculations implicitly assume uniform and perfect mixing of the conditioned air with that already present in the spaces. In practice of course such is not the case, particularly so in view of the fact mentioned previously of the disadvantage of multiple grilles. Furthermore, the layout of the spaces is usually more complicated than the simple rectilinear tunnel taken as an example; the result is a certain number of dead air pockets in the spaces from which humidity is fed to the main flow by diffusion only, a circumstance which may slow down considerably the attainment of equilibrium. According to the design of the spaces, the time required to reach equilibrium may be anything from a few hours to several days. In cases where the spaces involve separate rooms from which diffusion to the main flow is impossible, these rooms should be ventilated from the return flow (Fig. 2A, this month) and not from the main inlet duct (Fig. 2B).

In the previous calculations, equation 2 on p. 365, June HPAC, was integrated under the assumption that B, the coefficient of evaporation, remains constant regardless of location. This of course is not actually so because the air velocity, of which B is a function, is not the same

*The formula giving X for an infinite surface coefficient of heat transfer on p. 364 of the June HPAC should read

$$X = \sqrt{\frac{3.14\,q}{cd}\,t}$$

For a finite coefficient, the expression is more complicated.

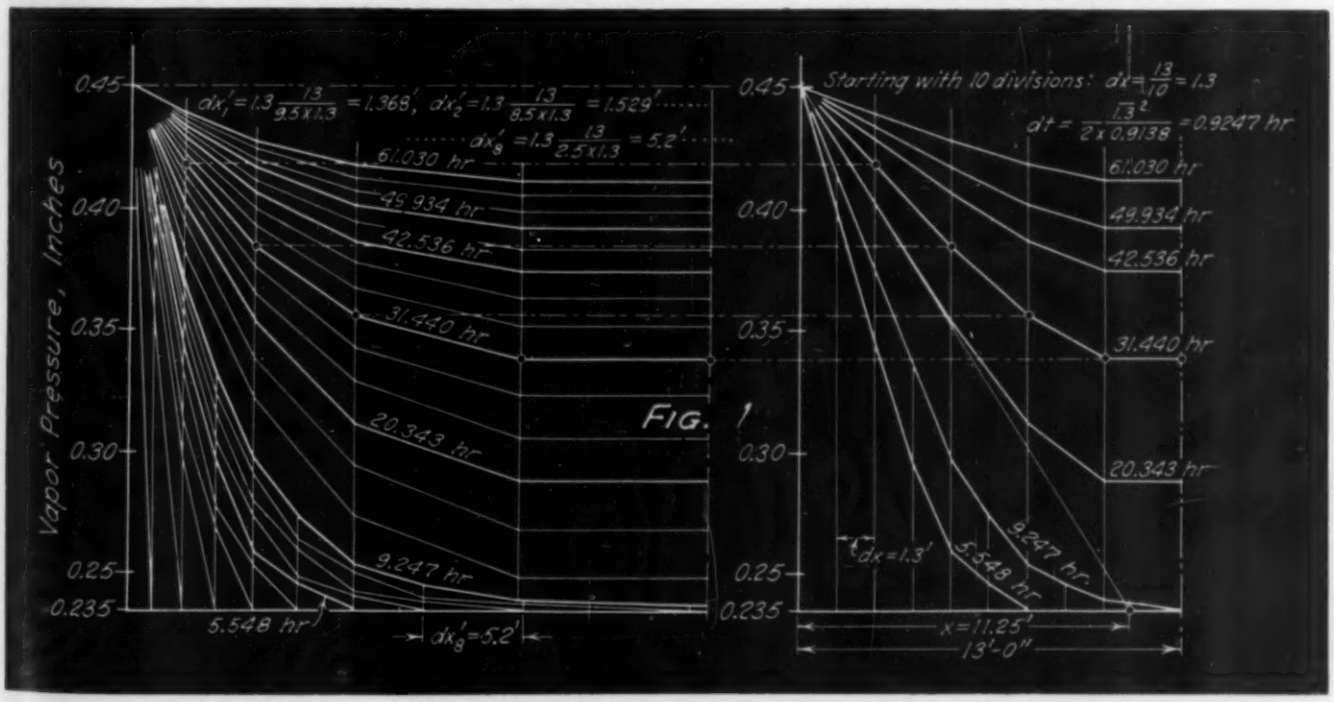


FIG. 1

throughout the spaces; this is due to dead air spaces and also stratification resulting from the presence of the initial air in the spaces, leakage, and opening of doors. The coefficient of vapor transfer depends also upon the nature and the shape of the surface, which is different for ceiling, floor, and walls. Variations of B with vapor pressure are negligible in the range considered.

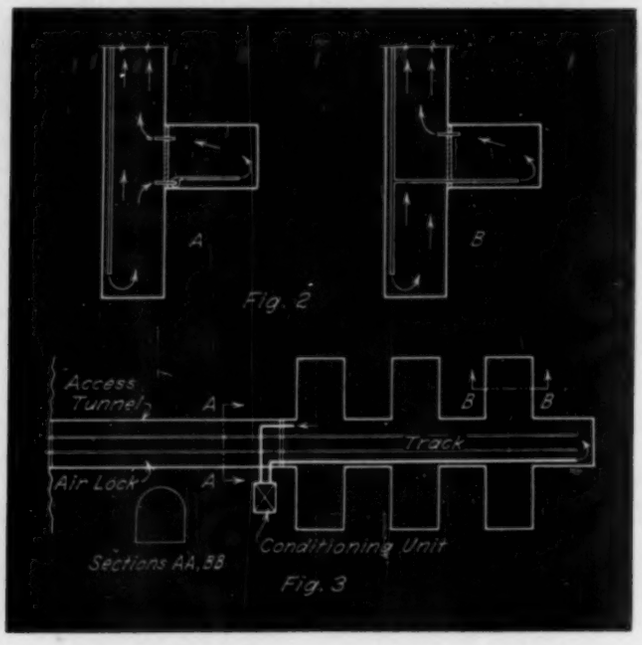
With ordinary concrete, or natural stone (reclaimed quarries), the rate of arrival of capillary water seems to be practically equal to evaporation; in other words, there is no noticeable drying of the walls and the coefficient of evaporation remains constant with time. With more impervious material, however, a certain drying of the walls may occur although such action would be very slow; in such case, the coefficient of vapor transfer decreases with time, which is of course a very favorable factor.

Effectively, let us call y the depth at which the walls have been dried; the vapor given off by the wet surface inside the walls must diffuse through the material before it can be taken up by the air at the outer surface where the coefficient of transfer is B; the overall coefficient of transfer B_T from wet surface to air is therefore given by:

$$\frac{1}{B_T} = \frac{1}{B} + \frac{y}{f'}$$

in which f' is the coefficient of vapor diffusion in the material. The depth y increases with time and also with the dryness of the air; effectively, stating that the velocity of regression of the evaporation surface results from the difference in its velocity in one direction due to evaporation and its velocity in the other direction due to the arrival of more capillary water, we have:

$$\frac{dy}{dt} = \frac{B_T \dfrac{(H - p_1)}{a + w}(w_1 - w)}{n} - v$$



in which n is the water content of the saturated material in lb per cu ft and v in ft per hr is the velocity of arrival of water corresponding to capillary tension and hydrostatic pressure. $a = 0.623$. w and w_1 are the absolute humidities in the air stream and at the wall surface, respectively, expressed in lb per lb of dry air. With these units, dy/dt is in ft per hr.

Considering that we have as yet no numerical data for the values of f' and v for various building materials, it is of little practical interest to carry the calculations further at this time. However, the above two equations show that, since B_T must be as small as possible, better results can be expected with high density building material (f' and n small), and if hydrostatic pressure is relieved and capillary tension in the material reduced (v small). The second of the above two equations shows that the walls will be dryer at the inlet end than at the outlet. It may be remarked that, once the walls have begun to dry, operation can no longer remain strictly adiabatic due to the heat taken up by the thickness y of wall material.

The actual velocity of flow through the spaces during operation being low, the humidity at the moment of shutdown will not be uniform throughout the cross section of the spaces and it will be found to rise continuously from the center towards the walls. Due to this circumstance, the time required after shutdown to affect a hygrometer placed in the center of the spaces, for instance, will be greatly reduced and usually such a hygrometer will start to register within two or three hours if not immediately. Diffusion from dead air spaces and zones of stratification where the humidity is high, as well as convection currents, will act to speed up very appreciably the humidity rise with time.

Actual results obtained in the underground ammunition dump shown in Fig. 3 were as follows:

Insulation of inlet duct	None
Volume of space	125,000 cu ft
Natural temperature of space	53.2 F
Initial conditions (not quite saturated on account of previous operations)	53.6 F — 0.00825 lb per lb
Air flow	110,000 cfm
Conditions of air delivered by conditioning unit	53.2 F wet bulb; 82 F dry bulb
Inlet conditions after loss in duct	61.5 F
The results were:	
Initial plant capacity	55 lb per hr
Capacity at practical equilibrium (wall evaporation)	33 lb per hr
Outlet conditions at equilibrium	56.5 F-0.0056 lb per lb
Time required to reach equilibrium	5 days

The conditioning is represented by *MM'ED* on Fig. 3, p. 365, June HPAC.

CONVERT, SAYS OPA

All commercial buildings which can convert to coal have been given the choice of converting or losing their oil rations by the end of January. Price Administrator Henderson said January 3 that boards should terminate all rations for any structure except a private dwelling unless: (1) Written proof is presented that arrangements have been made for conversion by a definite date within the current heating season. (2) The applicant has proved conclusively that conversion is impossible.

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AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

WARTIME PROGRAM

Science will contribute to winning the war and will ultimately provide a better world in the days of peace to come. During the past year, the Research activities of the Society have changed from a peacetime to a wartime basis.

Engineers are making their contribution to the war program and already 200 ASHVE members are serving in the armed forces and many times that number are directly in war production and construction work. The services of many members have been freely given to assist officials charged with fuel oil rationing.

The program of the 49th Annual Meeting has been geared to wartime tempo and the featured subjects deal with fuel conservation, manpower problems in the field of engineering, dehydration of food, and research on problems affecting human efficiency and health.

The Council has adopted a wartime policy of holding meetings only when they are essential to carry on necessary Society business and to aid in winning the war.

Engineers have a big stake and are doing their part.

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Army Fuel Consumption Studies of 1941-42

By L. C. McCabe,* Washington, D. C., S. Konzo,** Urbana, Ill., R. E. Biller,† Washington, D. C.

SUMMARY—The problem of allocating fuel to the hundreds of army camps in adequate quantities and at the proper time is but one of the problems that required special study by the Corps of Engineers. Actual field studies were conducted at ten camps on a great number of selected buildings for an entire heating season. Empirical values were obtained for the "Space Heat Factor", which was in units of "Lb of standard fuel per 1000 sq ft of floor area per degree-day." These values are included in the revised procedure based on these fuel studies which has been adopted by the Corps of Engineers

Introduction

THE ARMY is one of the largest consumers of fuel in the continental area of the United States. Each camp is equivalent in size and number of buildings to a town or city. The aggregate of hundreds of camps containing thousands of buildings, each of which requires fuel for space heating, cooking, water heating, or process steam presents a fuel demand and a fuel problem of great magnitude. Such phases of the problem as fuel selection, fuel specifications, procurement of funds, fuel inspection, ash disposal, and heating plant maintenance require most careful planning and execution. One of the major problems has been the proper allotment of fuel for these purposes. Too small a fuel allotment may result in sudden overload demands for fuel in winter, too large an allotment may result in carelessness in use, loss by spontaneous combustion, overload of limited storage space, and unjustified inroads on the industrial and domestic supply. The problem is complicated by the fact that camps are located in areas with all gradations between year 'round heating and short seasonal demands, that almost every available type of fuel is used, that the personnel changes continually, that every type of heating equipment is used, and that buildings ranging from permanent hospital structures to tents are heated.

In the winter of 1941-42, the Office of the Chief of Engineers of the United States Army made a study[1] of the problem. The University of Illinois, Engineering Experiment Station, provided consulting service and the U. S. Weather Bureau supplied the necessary weather information. This paper presents the general nature of attack of the problem and the method of determining fuel requirements recently adopted by the Army.

Limitations of Former Method of Fuel Allotment

Prior to the present building program of the United States Army, the determination of the total quantity of fuel required for heating buildings was made by the application of Equation (1).[2]

The term *Hours of Operation at Total Capacity* was based on average temperatures as shown by U. S. Weather Bureau records and predetermined factors compiled by the Quartermaster General. Specific details as to the method used in determining the *Hours of Operation* are not available, but by reconstruction of existing data it is probable that the term was derived from Equation (2).

With reference to the term *Standard Fuel*, the following quotation from Army Regulations Number 30-1620 is of interest.

The standard fuel referred to is anthracite coal having a content of 12,500 Btu per pound and not more than 10 per cent of ash nor more than 10 per cent of volatile matter. This coal has been taken as standard for the reason of its uniformity of quality, but this standard is not to be construed as indicating that it is to be used in preference to any other fuel.

For purposes of converting the allowance, expressed in standard fuel as shown in Equation (1) to

$$\left\{\begin{array}{c}\text{Lb Standard}\\ \text{Fuel}\\ \text{per Building}\\ \text{per Season}\end{array}\right\} = (\text{Factor}_1)\ (\text{Factor}_2) \left\{\begin{array}{c}\text{Hr. of Operation}\\ \text{at Total Capacity}\end{array}\right\} \quad \ldots\ldots\ldots [1]$$

in which,

a. For steam heat, $\text{Factor}_1 = 0.04$ lb standard fuel per hour per square foot of direct radiation.
$\text{Factor}_2 =$ square feet of direct radiation or its equivalent, including surface of uncovered pipe used for heating the building, exclusive of risers.

b. For hot water heat,
$\text{Factor}_1 = 0.0272$
$\text{Factor}_2 =$ square feet of direct radiation.

c. For warm-air furnaces, stoves and fireplaces,
$\text{Factor}_1 = 5$ lb of standard fuel per hour per square foot of grate surface.
$\text{Factor}_2 =$ square feet of grate surface.

$$\left\{\begin{array}{c}\text{Hours of Operation}\\ \text{At Total Capacity}\\ \text{per Season}\end{array}\right\} = \frac{24 \times N \times (70 - t_a)}{(70 - t_d)} \quad \ldots\ldots\ldots [2]$$

in which,
$24 =$ hours per day
$N =$ number of days in heating season
$t_a =$ average outdoor temperature during heating season, in degrees Fahrenheit
$t_d =$ outdoor temperature assumed for design of plant, in degrees Fahrenheit

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For presentation at the 49th Annual Meeting of the American Society of Heating and Ventilating Engineers, Cincinnati, Ohio, January, 1943.

[1]This study was authorized by Col. G. F. Lewis, Chief of Repairs and Utilities Br., Office of Chief of Engrs., and was directed by Maj. L. C. McCabe, Chief of Heating and Refrigeration Section of that office. Acknowledgment is made to W. A. Hepburn, Capt. J. B. Cordiner, and J. J. Bowe, Office of Chief of Engrs. who participated in the study.

The Weather Bureau studies which will be reported in separate publications were under the direction of J. P. Kohler and H. C. Thom.

Professors S. Konzo and A. P. Kratz, Department of Mechanical Engineering, University of Illinois, served as specialist consultants.

[2]Army Regulations No. 30—1620, Quartermaster Corps, issued June 10, 1932.

the fuel actually in use, Equation (3) was used:

$$\left\{\begin{array}{l}\text{Lb Fuel}\\ \text{Actually}\\ \text{Allowed}\end{array}\right\} = \frac{\text{Lb Standard Fuel}}{\text{Equivalent factor}} \quad [3]$$

The extensive table of equivalent factors given in the same publication for all types of fuel shows that for solid fuels the equivalent factor became smaller as the ash content and volatile matter content increased.

The method of determining fuel allowances based on the use of the preceding equations was reasonably satisfactory, particularly after actual operating experience indicated the modifications necessary to meet local conditions.

During 1940-41 a critical analysis of the prevailing method of determining fuel allowance indicated that the method was deficient when applied to newer camps composed largely of temporary type buildings, and that a thorough revision of the method to conform to present-day commercial practice was desirable. Some of the deficiencies in the prevailing method may be enumerated as follows:

a. The numerical values for Factor$_1$ in Equation (1) were determined from a limited number of tests[3] on permanent type buildings located in and near Washington, D.C. and probably would not be applicable to the temporary type structures that constitute a large proportion of the new army building program.

b. The use of the Factor$_2$ involving the square feet of installed radiation, was equivalent to basing the fuel allowance on the calculated heat loss. For a given type of building, the amount of installed radiation would be different for each design temperature zone, so that for purposes of checking, it was considered more desirable to obtain a constant that would be uniformly applicable over the country and which would be independent of the design outdoor temperature.

c. The allowance of 5 lb of coal per hour per square foot of grate surface for warm-air furnaces and stoves was not considered applicable to present-day equipment or to the temporary type buildings. In addition, the wide range of furnace sizes used over the country to heat even the same type of building would make the process of checking fuel allowances an exceedingly laborious task.

d. The numerical values for *hours of operation at total capacity* depended not only upon the mean temperature during the heating season and the length of the heating season, both of which could be obtained from the Weather Bureau, but also upon the design outdoor temperature, which quite frequently is chosen arbitrarily by the engineer.

e. The extensive tables of equivalent factors for coal incorporate the effects of ash, volatile matter, and size of coal, but neglect both the calorific value and fixed carbon content. The evaluation of the relative effectiveness of coals has been considered as a separate problem and results obtained will be presented separately.

f. The fuel study demonstrated that with certain adjustments in quantities provided by Army Regulations 30—1620, the per capita basis was the most satisfactory basis for computing fuel allowances for laundry, water heating and cooking.

[3] *Fuel Allowances*—A Thesis Presented for the Degree of Mechanical Engineer by James Henry Platt, B.M.E., the Ohio State University, 1924.

Objectives of Field Studies

In view of the limitations inherent in the methods of determining total fuel requirements outlined in Army Regulations 30-1620, the Office of the Chief of Engineers authorized a field study of fuel consumption at actual field installations. The following objectives were considered in planning the test program:

1. A method utilizing the degree-days for each locality was to be used for space heating.

2. A constant designated as the *space heat fuel allowance*, or the pounds of standard fuel per 1000 sq ft of floor area per degree-day, was to be determined by test for the various types of buildings.

3. A simplified procedure was to be established for calculating the fuel requirements for heating all buildings.

4. Additional data were to be gathered upon which to establish revised allowances for water heating, cooking, and laundry purposes on the per capita basis.

Method of Procedure

Selection of Buildings for Study: Located geographically as indicated on map (Fig. 1), 10 different camps were selected for the field studies. These camps represent wide variations in weather conditions and utilize the three general types of fuel such as coal, gas and oil.

Fig. 1—U. S. Army fuel consumption study posts observed

Table 1—Typical list of buildings under observation

Fort Devens State Mass.		
TEMPORARY BUILDINGS		
Type of Building	Sq Ft Floor Area	No. of Bldgs. Observed
Barracks: 63-Man ...	4,720	3
Mess: 118 Officer	1,980	1
Mess: 210-Man	2,664	2
Administration: A-5 ..	1,144	1
Administration: A-22..	3,200	1
Exchange: E-3	3,663	1
Officers' Quarters: OQ-40	7,670	2
Recreation: RB-1	3,663	1
Motor Repair Shop: SP-2	3,108	1
Infirmary: I-2	2,056	2
Company Storehouse and Administration: SA-2	1,296	1
Theater: TH-3.....	10,724	1
Storehouse: SH-13 ...	9,190	1
PERMANENT BUILDINGS		
Officers' Private Quarters: OQ	2,044	2
Non-Commissioned Officers' Private Quarters: NCOQ	858	2
Enlisted Man's Barracks: EMB	66,000	1

Since the buildings in any given post may be many hundreds in number, and the types of buildings may exceed 100, an intensive fuel survey of each building at each post was prohibitive in time and expense. Instead, the total number of buildings to be studied at each post was limited to from 30 to 40, and by judicious selection a representative sample of the various types of buildings and fuel usage was obtained. The barracks-type structure constitutes the largest proportion of the total number of buildings at any post, in some cases comprising over 50 per cent of the total floor area at the post. As shown in the typical list given in Table 1, from 3 to 6 barracks were placed under observation at each project, and an average fuel consumption was obtained for this predominant type of structure. As a result of the sampling procedure, approximately 90 to 97 per cent of the total floor area at any post can be considered as included in the study. Fig. 2 presents several of the types of buildings studied showing the general construction.

Observation of Fuel Consumption: An engineer, located at each of the 10 posts, recorded weekly fuel consumptions of from 30 to 40 separate buildings during the heating season of 1941-1942. In all cases the fuel supplied to the buildings under study was separately

Fig. 2—Types of buildings studied showing general construction

recorded, and precautions were taken to insure that the fuel assigned to a given building was not diverted to some other building or use. A typical weekly summary sheet for all the buildings is shown in Fig. 3.

In these studies no attempts were made to vary or improve the normal routine and handling of the heating plants and the buildings. The data obtained may be considered as typical of actual operation in the field.

Factors Affecting Fuel Consumption for Space Heating: The weekly fuel consumption for any given building and heating plant will be dependent upon the following climatic variables:

1. Temperature difference between indoors and outdoors.
2. Wind effects.
3. Sun effects.
4. Moisture effects.

Of these four variables, the difference in temperature between indoors and outdoors is the predominant factor, so that if the weekly fuel consumption is plotted on a curve against the temperature difference, or the equivalent degree-days for the week, a correlation can be expected.[4] Typical curves showing data for barracks fired with coal are shown in Fig. 4.

It may be observed from Fig. 4 that the curves tend to converge to the zero point. An examination of the data for all types of buildings and from all 10 posts, indicated that heating was required whenever the mean outdoor temperature ranged from about 63 to 67 F, so that a base temperature of 65 F for the determination of the degree-day values appears to be adequate for this type of service. The only exception was in the case of hospital buildings and clinics, in which a base temperature of 70 F seemed to be more appropriate. Rather than introduce a new base temperature for degree-day calculations, merely to take care of a relatively small part of the total heating requirements, a uniform base temperature of 65 F, which is the commercially recognized value, was accepted and fuel requirements for hospital purposes determined on a partially different basis. The latter will be discussed more in detail presently.

It is apparent from Fig. 4 that as the severity of the weather increased, the weekly coal consumption also increased. Furthermore, in general, the consumption did not increase proportionally with increases in the degree-days for the week. Relatively less coal was used per degree-day in severe weather than in mild weather. This experience, which is different from that frequently found in tests of field installations of domestic and commercial buildings, is considered in more detail in the following sections:

Determination of Space Heat Factor: The basic data shown in Fig. 4 are not in a form suitable for later application, since in applying the data for the purposes of estimating fuel consumption it would be necessary to obtain the degree-days per week for each week in a given locality, and then to obtain the fuel consumption for each week from the figure. A more generalized factor was required that would facilitate the application of data.

$$\left\{\begin{matrix}\text{Lb Standard Fuel}\\ \text{per Building}\\ \text{per Season}\end{matrix}\right\} = (F)\left\{\begin{matrix}\text{Degree-}\\ \text{days per}\\ \text{Season}\end{matrix}\right\}\left\{\begin{matrix}\text{Design Heat Loss}\\ \text{of Building in}\\ \text{Btu per hour}\end{matrix}\right\} \quad \ldots\ldots \quad [4]$$

One obvious generalization would be to determine a factor, *F*, which would have units of *pounds of standard fuel per degree-day per Btu per hour heat loss*, and which would be used in Equation (4). The difficulty with this equation is that the last term, involving the calculated heat loss of the building, is not a constant for the same type of building. The calculation of heat losses from a building is not immune from individual interpretations, nor are outdoor design temperatures positively determined for each and every part of the country. Hence, in spite of the fact that a single factor, *F*, might be obtained which would be applicable to more than one type of building on the post, the obvious difficulties in obtaining and checking the design heat losses for even a single type of building for several hundred posts eliminated from consideration this obvious approach.

A barracks building of standard design, whether located in Alaska or Florida, may have widely varying design heat losses, but does have one feature of constancy, and that is the physical size. Hence, for the purposes of the Army, a factor based upon some physical dimension of the building was most acceptable. This factor, which has been termed the *Space Heat Fuel*

[4] In University of Illinois Engineering Experiment Station Bulletins Nos. 189 and 246, data are presented showing the effects of wind and sun on fuel consumption in Research Residence. In extremely high winds fuel consumption is greater than normal. There are no adequate means, however, of obtaining an over-all index of weather that would properly evaluate the effects of the four variables. Furthermore, it is questionable whether a single index of such a nature would be generally applicable to all types of building structures. As a result of this difficulty, the only practical method has been to plot fuel consumption against the predominating factor, which is temperature difference, and then to extend the period of fuel observation over a long period of time, so that periods of high wind, low wind, high sunshine, low sunshine, rain, snow, and sleet are all included. A curve drawn through the average of points secured in this manner will represent average weather conditions for the locality. This procedure requires a test period that may extend over several months. Experience has indicated the danger of making conclusions based upon test periods that are less than a month in duration. In the final analysis of test data secured from all 10 posts, the average wind and sun effects were tabulated and scrutinized, but no consistent results could be observed which might indicate that a special correction factor for either factor was required. An examination of weather data for the United States indicates that with the exception of a few localities, the average wind velocity in winter months does not exceed about 12 mph. Later experience may indicate that an empirical correction should be applied to fuel allotments for these few exceptions.

Allowance, or *SHFA*, is in units of *Pounds of standard fuel per* 1,000 *sq ft of floor area per degree-day*, and is used in Equation (5):

$$\left\{\begin{array}{c}\text{Lb Standard Fuel}\\ \text{per Building}\\ \text{per Season}\end{array}\right\} = (SHFA)\left\{\begin{array}{c}\text{Floor Area}\\ \text{in thousands}\\ \text{of sq ft}\end{array}\right\}\left\{\begin{array}{c}\text{Degree-}\\ \text{days per}\\ \text{Season}\end{array}\right\} \quad \ldots\ldots \quad [5]$$

In this case, the values for floor area are readily available in the Army records and are constant for a given type of Army standardized construction, and degree-day data for each post are available from U. S. Weather Bureau computations for all posts of the Army. Knowing the actual amount of fuel consumed at all test buildings, the floor area of each, and the number of degree-days during the period of observation, *SHFA* were calculated and used in the final analysis of the data.

Characteristics of Space Heat Fuel Allowance: In Fig. 5*a* are shown generalized diagrams plotted on the same bases as those in Fig. 4. Four separate cases are shown, as follows:

Case 1. Fuel consumption is a straight-line function of degree-days, and is exactly proportional.

Case 2. Fuel is required when the mean outdoor temperature is greater than 65 F and is a straight-line function of degree-days.

Case 3. Fuel is required only when the mean outdoor temperature is less than 65 F and is a straight-line function of degree-days.

Case 4. Fuel consumption is not proportional to the degree-days. The curves shown in Fig. 4 are similar to this case, as were the curves representing the data for other types of buildings.

If the units in the vertical ordinate of Fig. 5*a* are converted to units of *SHFA*, the generalized relationships shown in Fig. 5*b* are obtained. *Case 1* is the only case which would provide a constant value over the entire range of weather conditions. Actually, nearly all of the data obtained in these studies were similar in character to *Case 4*. That is, for any given post, the *SHFA* increased as the weather became milder, and decreased as the weather became more severe. Furthermore, a given type of building located in the South, where the degree-days were small, as compared with the same type of building located in a colder climate, used relatively more fuel than the ratio of total seasonal degree-days would indicate. This could be accounted for on the basis that any one or all of the following conditions existed:

1. That the efficiency of combustion increased as the heating demand increased. This supposition does not seem tenable in view of the fact that for coal-fired equipment the efficiency usually decreases with an increase in combustion rate.

2. That either due to differences in clothing or differences in acclimatization, a higher indoor temperature is required in early fall and late spring than in the middle of winter. Records of air temperatures in the buildings did not indicate that noticeably higher indoor temperatures were being maintained in milder weather than in severe weather. As a matter of fact, from the standpoint of equal comfort, experience in domestic heating practice has indicated that in severe weather a higher setting of the room thermostat is necessary to counteract the influence of cold walls and cooler temperatures in the living zone.

3. That the heat loss from the buildings was relatively greater per degree difference in temperature from indoors to outdoors for mild weather than for severe weather. This supposition seems to be the most likely explanation of any that have been

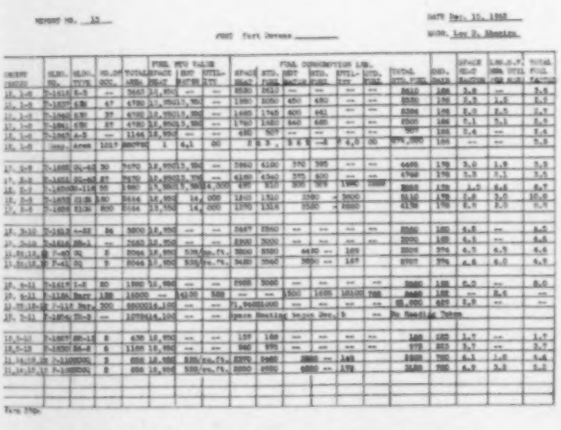

Fig. 3—Degree-day study field data

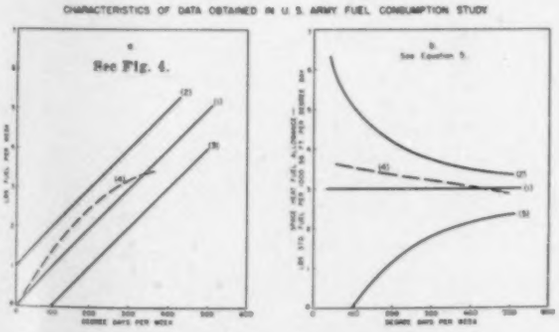

Fig. 5—Generalized diagrams showing characteristic trends of space heat factor

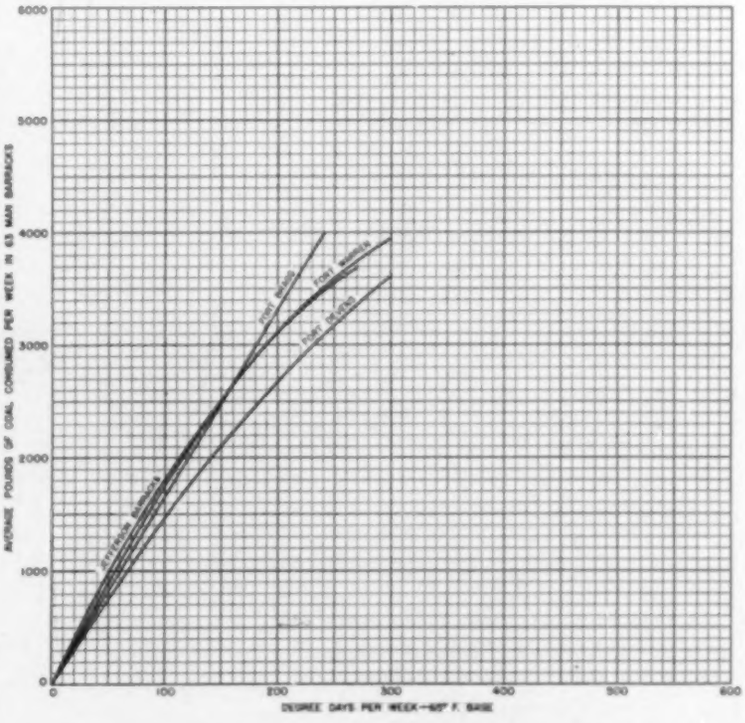

Fig. 4—Coal consumption for barracks type building

Case 1. Fuel consumption proportional to degree-days.
Case 2. Fuel required when mean outdoor temperature exceeds 65 F.
Case 3. Fuel required when mean outdoor temperature is lower than 65 F.
Case 4. Fuel consumption not proportional to degree-days.

offered. The prevailing practice is to allow considerable open window ventilation in the building, both night and day. As the weather becomes more severe it is probable that the windows are not opened as widely, and that as a consequence the interchange of indoor and outdoor air decreases.

If Curves 2 and 3 in Fig. 5*a* represent the upper and lower limits of the range of data, for which Curve 1 is the average, the derived Space Heat Factors will show very wide deviations from a mean value for small numbers of degree-days per week and will show smaller deviations from the mean value for severe weather. This is illustrated in Fig. 5*b* in which the curves for Cases 2 and 3 converge towards the right. A study of the actual data showed that the tendency was characteristic of all the data.

Application of Space Heating Fuel Allowance

Application to Different Temperature Zones: For a given type of building the data from all of the posts were plotted on a single sheet and average curves were drawn through the hundreds of points. The final summary of data for several types of buildings is shown in Fig. 6. This summary represents the end results of one of the most comprehensive field surveys of fuel requirements ever attempted.

It is apparent from Fig. 6 that a constant value for the *SHFA* cannot be used for two buildings of the same type located in widely divergent climatic conditions. If, however, the mean outdoor temperature during the heating season is known, then the corresponding weekly degree-days can be evaluated, and the values for *SHFA* can be read directly from Fig. 6. It has been proposed that all calculations should be based on *SHFA* for a mean outdoor temperature of 45 F, and that corrections should be made for other temperatures depending upon the slope of the line representing the *SHFA*.

For Army purposes, this procedure has been modified somewhat. Based on a correlation of degree-days and the average temperature, the value of the correction factor was made dependent upon the average number of degree-days occurring per season.

Weather Bureau Data: As an integral part of this project the U. S. Weather Bureau supplied the following data for the principal weather stations in the United States adjacent to the posts.

1. Station.
2. Degree-days per year (65 deg base), mean value.
3. Degree-days per year (65 deg base), based on 75 per cent frequency.
4. Degree-days per month for each month, corresponding to Item 3.
5. Per cent of yearly degree-day value represented by each monthly value.
6. Starting date of heating season; that is, when mean daily temperature reaches 65 F.
7. Ending date of heating season; that is, when mean daily temperature rises to 65 F.
8. Length of heating season.
9. Mean daily temperature during heating season.
10. Average wind velocity during heating season and prevailing direction.
11. Index of sunshine hours during heating season.

Quite extensive tables and charts are currently available[5] that present weather data for the United States. Up to the present time, however, the U. S. Weather Bureau has not officially issued comprehensive tables or maps that cover the preceding items. The official report of the Weather Bureau is to be published at a later date.

Cantonment Type Station Hospitals

The buildings comprising an Army station hospital differ in one respect in that they are heated centrally from the hospital boiler house.[6] Hot water and some steam for mess purposes are provided from this source also. Because of these conditions, it is necessary to estimate fuel requirements on a different basis, namely, tons of standard fuel per 1000 sq ft of floor area per year.

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[5] *Degree-Day Handbook* and *Air Conditioning Engineers' Atlas* by The Industrial Press.

[6] An Army cantonment type station hospital consists of a number of small, separate one-story buildings (a 1000-bed hospital of this type will normally consist of 75 to 80 buildings). All are interconnected by means of enclosed walkways. In these walkways are located the mains of the steam distribution system.

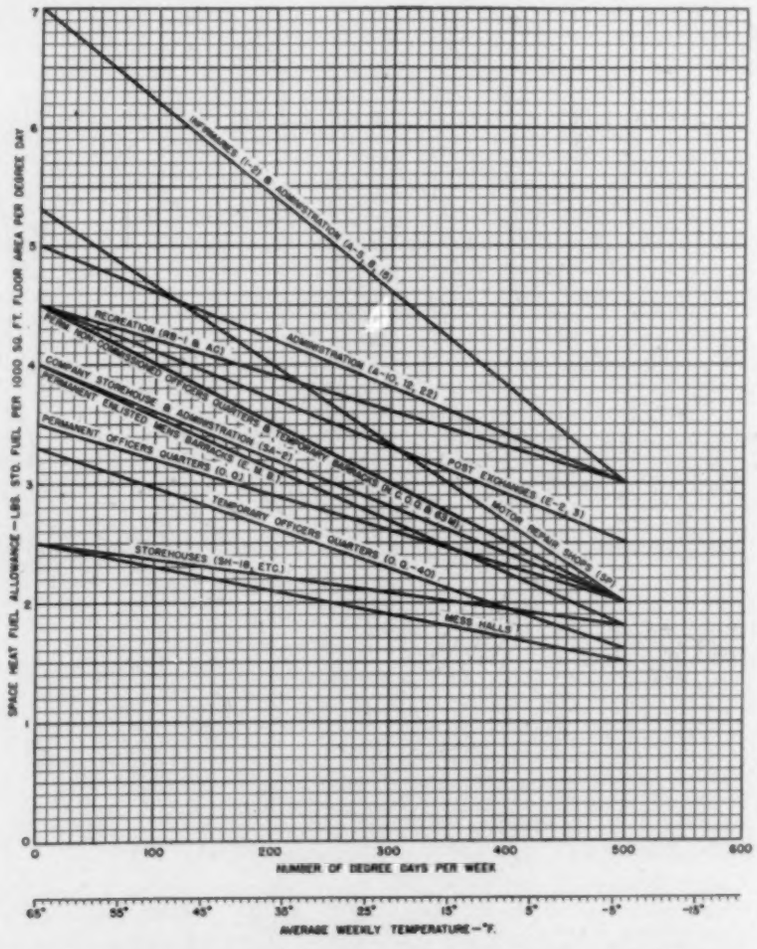


Fig. 6—Summary of weekly space heat data for indicated types of buildings

Yearly fuel consumption figures were gathered from station hospitals distributed geographically throughout the continental United States. Knowing the floor area and degree-days for the season, the fuel required per 1000 sq ft floor area per year was calculated for each post. These values were plotted against degree-days per year, resulting in Fig. 7. Table 7 of the appended directive gives a tabular summary of fuel allotment for this service. Station hospitals utilizing coal, gas and oil were included in this survey.

Water Heating, Cooking and Laundry

The fuel required for water heating, cooking and laundry purposes has been determined on the per capita basis, results of which are presented in Tables 8 and 9 of the appended directive. Data for water heating and cooking were collected from the barracks and mess halls, respectively. The per capita fuel requirements for cooking and water heating vary little with the number of men accommodated. Fuel required for laundry purposes was calculated from fuel consumption and post population records. (Table 9.)

General Notes

As might be expected from the wide spread of locations and fuels encountered in Army practice, considerable variations in fuel consumptions from an average value were obtained even for the same type of building. The empirical approach discussed in this paper, in which the average of hundreds of plotted points was obtained, does provide a starting point from which a reasonable fuel estimate can be made. The use of the mean seasonal degree-days as a basis of obtaining the normal fuel consumption, likewise enables the Office of the Chief of Engineers to provide for an increased fuel allotment when the actual heating season is more severe than normal. If experience indicates that the fuel consumption for any given post is consistently greater than the average allotment for that post, the combustion engineers will at least be able to concentrate their attention on that post to find the reason for the variance.

At one post, in which the fuel used was petroleum coke, the fuel consumption was considerably greater than when coal was used. Petroleum coke is extremely responsive to changes in draft and it is questionable whether such a fuel can be efficiently burned in Army service unless extra precautions are taken to train the firemen in the proper control of the drafts and in the proper method of handling the fuel.

Two regions in the United States have weather characteristics that differ appreciably from those in the rest of the country. These regions are the San Francisco Bay area and the Puget Sound area in Washington. In both regions a mean daily outdoor temperature less than 65 F may be obtained in every month of the year. Hence, with a hand-fired plant there may be a tendency to keep the fires going and to burn some fuel even when no heating demand exists, merely to save the labor of relighting the fires every time the weather turns cool. For such regions the fuel consumption may be greater than the number of degree-days would indicate is necessary. Experience may indicate the necessity of providing for a small factor of safety for the coal consumed during such hold-over periods.

The following directive for computation of fuel allowances (degree-day data deleted), which was

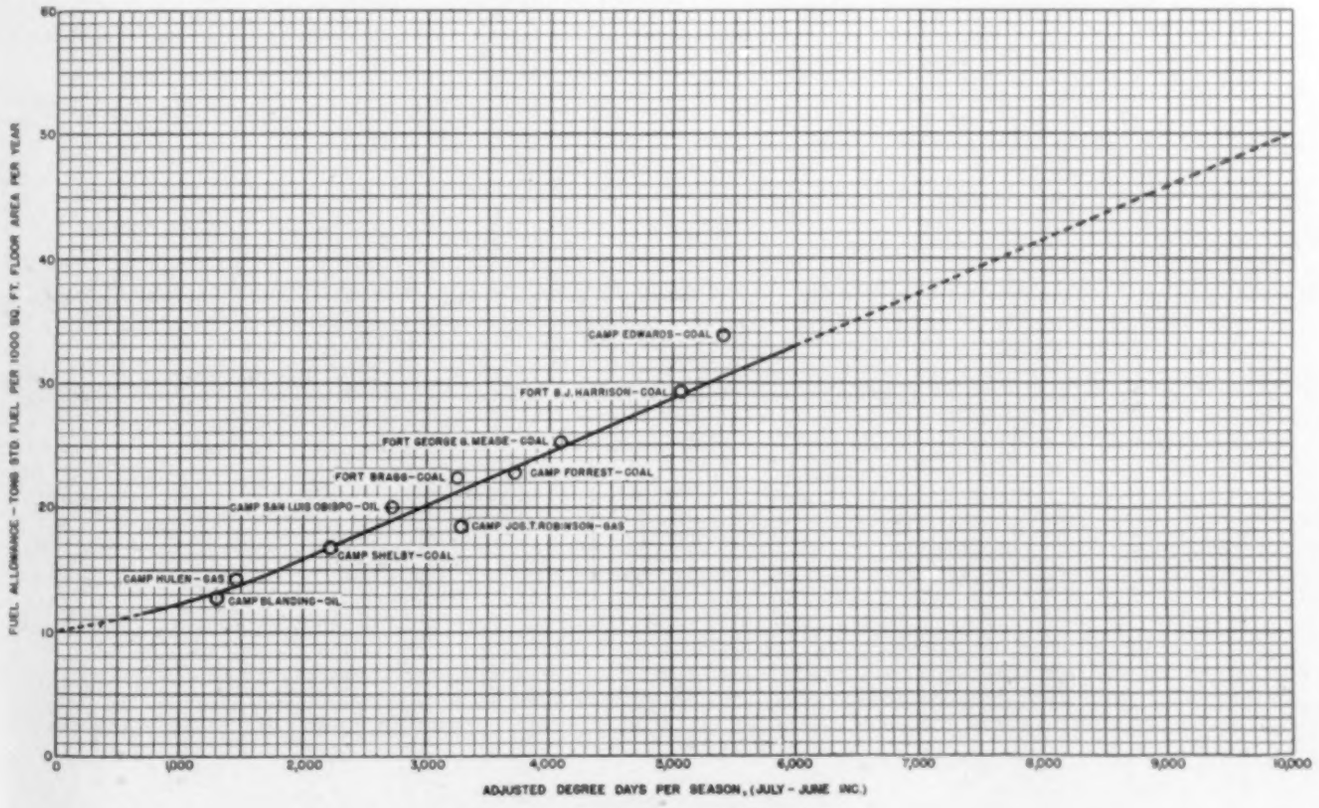


Fig. 7—Hospital consumption data

released by the Adjutant General on October 9, 1942, illustrates the application of the fuel consumption study to the determination of fuel requirements for Army posts, irrespective of magnitude and location.

COMPUTATION OF FUEL ALLOWANCES[1]

This study demonstrates that the total fuel requirements of a post are divided functionally into the following items:

a. Space heating for all buildings except the cantonment type hospital area.
b. Total fuel required for the cantonment hospital.
c. Total fuel required for hot water heating and cooking except the cantonment hospital area.
d. Fuel for laundry purposes.
e. Fuel purchased for resale.
f. Other miscellaneous uses.

General Discussion

1. *Building groups:* All buildings have been classified into 7 groups according to their fuel requirements for space heating. Table 2 shows the building types for each group.

2. *Fuel allowance factor:* The fuel allowance factor for space heating per 1,000 sq ft of floor area per degree-day was determined for each group of buildings from field data. These allowances are given in Table 3.

3. *Degree-days:* The degree-day is a unit used to express heating requirements when the daily average temperature falls below 65 F. If the average temperature of a 24-hour period is 45 F, the heating requirements of this period are equivalent to 20 degree-days. Daily degree-day values are added to obtain yearly totals. The number of degree-days assigned to calculate heating requirements in certain localities are tentative, pending determination of exact values by the U. S. Weather Bureau. These tentative values include a factor of safety of such magnitude that they will rarely be exceeded. Table 1 contains a list of posts and stations together with an adjusted number of degree-days for each location.

4. *Climate factor:* Fuel consumption data indicate that as the outdoor temperature becomes milder, more fuel is required to heat a given unit of space per degree-day. A climate factor has been introduced which allows more fuel per unit floor area per degree-day in a warmer locality. The value of this factor varies with the total number of degree-days per year as indicated in Table 4.

5. *Fuel burning factor:* This factor compensates for differences in the fuel burning efficiency of coal, gas, and oil as indicated in Table 5.

6. *Fuel Conversion factor:* This factor is used to convert standard fuel quantities to quantities of fuel as burned at the post. See Table 6.

7. *Cantonment type hospital allowance:* Table 7 contains the fuel allowance for cantonment type hospitals per 1,000 sq ft of floor area per year. If the adjusted degree-day value falls between values shown in the table, factor values will be interpolated to obtain the correct allowance.

8. *Hot water and cooking allowance:* Table 8 contains separate fuel allowances for hot water heating and cooking on a per capita basis, when either coal, gas, or oil is used.

9. *Laundry allowance:* The fuel allowance for laundry purposes is on the per capita basis. Table 9 contains the allowances for coal, gas or oil.

10. *Form No. 423* (Fig. 8): This form will be executed annually in quadruplicate. The original and one copy will be forwarded by January 1 to the Chief of Engineers, Attention of Repairs and Utilities Branch. One copy will be retained by the division engineer and one by the post engineer. This form will also accompany all supplemental requests for fuel due to additional housing capacity. Only the additional construction or other items on which the estimate of additional fuel is based need be listed on the supplemental form.

[1]Inclosure No. 1 to Memorandum SPX 463, (10-2-42) SPEGC-MP-R-M, October 8, 1942.

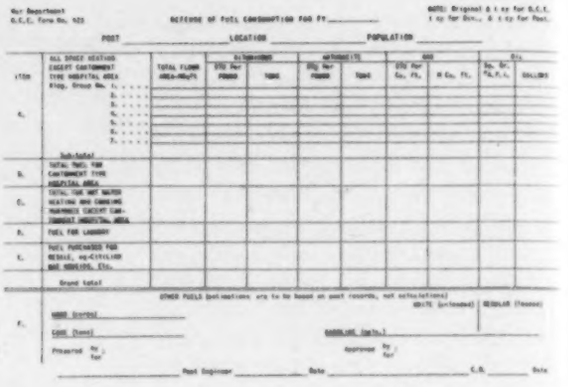


Fig. 8—O.C.E. Form No. 423

Directions For Completing Form No. 423

1. Fill in spaces for fiscal year, post, location, and population. The latter includes all officers and enlisted men.

2. Group all buildings at the post in their respective classifications as indicated in Table 2, and compute the total floor area of each group in M (thousands) square feet. Insert these values in total floor area column.

3. Sample calculation for items *a* to *f* required on Form No. 423 (Fig. 8). Assume Post X is located in a 6,000 degree-day area and the post population is 40,000 men. Buildings in group 1 have a total floor area of 500,000 sq ft. Bituminous egg coal containing 13,500 Btu per lb is used for space heating, cooking, and hot water heating. The cantonment type hospital has a floor area of 180,000 sq ft. Bituminous coal having 13,000 Btu per lb is used at the hospital and laundry boiler houses. (The Btu value of the coal will be assumed to be the average *as received* value of the coal used for that purpose during the preceding year.)

ITEM *a*. Space heating. (Similar calculation to be made for each building group.)

Table 2—Building groups

TEMPORARY BUILDINGS

No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Enlisted man's barracks: 63 M 74 M 45 M 25 M Recreation buildings: RB-1, 2 & 4 ORBL-3 Post exchange: E-1, 2, & 3 CPX-1 Guard houses: GH-1 & 2 UGH-12, 24 & 36 CGH-50	Officers' Quarters with and without mess: OQ-5,7,11, 17, 40, BOQ-32, 40, 44 OQM-40 BOQM-28, 36	Officers' and enlisted man's messes: OM-118 EM-72, 112, 152, 170, 172, 210, 228, 248, 250, 300 Storehouses: SH-18, 19, 20, 21 (partially heated storehouses not considered). Sheds: MS-2	Administration buildings: A-4 to A-22 ADM-1 IBA-1 Infirmaries and clinics (outside of cantonment hospital area): I-1 to I-5 DC-1 & 2 Service clubs: SC-1, 2, 3, & 4 Schools: SCS-1 SB-12 Trainer buildings: L7 SH-9 (Mod.)	Motor repair and utility shops: SP-1, 2, 6, 8, 9, 10, 11, 12, 13, 14 MRS-1 & 2 Mechanized shops: AFS-1 BES-1 & 2 TRS-1, 2, & 3 All theater of operation type construction regardless of building type.	Storehouse and company administration: SA-1 & 2 Storehouse recreation and company administration: RSA-1, 2, & 3 Company maintenance and arms room: CMS-1	All tentage and hutment construction.

PERMANENT BUILDINGS

NCO private quarters.	Officers' private quarters; administration or headquarters buildings.			Hangars: DH-1 & 2 OBH-1 & 2 Post exchanges, theaters, chapels, and any miscellaneous heated permanent buildings.	Enlisted man's barracks with or without mess. Hospital.	

Table 3—Space heat fuel allowance

Building group No.	Allowance—lb std. fuel per M sq ft floor area per degree-day
1	3.8
2	3.0
3	2.3
4	5.1
5	4.4
6	3.4
7	7.0

Table 4—Climate factor

Degree-day range per year	Factor
0-3500	1.08
3500-7500	1.00
7500-up	0.92

Table 5—Fuel burning factor

Fuel	Factor
Coal	1.00
Gas	0.88
Oil	0.93

Formula: (fuel allowance from Table 3) × (floor area, M sq ft) × (degree-days per year from Table 1) × (climate factor from Table 4) × (fuel burning factor from Table 5) × (fuel conversion factor from Table 6) divided by 2,000-tons, MCF gas, or gallons oil.

3.8 × 500 × 6,000 × 1.00 × 1.00 × 0.93 ÷ 2,000 = 5,300 tons

Enter 5,300 tons under the bituminous heading on Form No. 423 opposite building group No. 1.

ITEM *b*. Total fuel for cantonment type hospital.

Formula: (fuel allowance from Table 7) × (floor area, M sq ft) × (fuel burning factor from Table 5) × (fuel conversion factor from Table 6) = tons, MCF gas, or gallons oil.

33 × 180 × 1.00 × 0.96 = 5,700 tons

Enter 5,700 tons on line B in bituminous coal column.

ITEM *c*. Total fuel required for hot water heating and cooking except cantonment hospital area.

Formula (separate calculations for hot water and cooking are required where two fuels are used): (fuel allowance from Table 8) × (post population) × (fuel conversion factor from Table 6) = tons, MCF gas, or gallons oil.

0.75 × 40,000 × 0.93 = 27,900 tons bituminous, for hot water heating and cooking purposes.

Enter 27,900 tons in bituminous column for item *c*.

ITEM *d*. Fuel for laundry purposes.

Formula: (fuel allowance from Table 9) × (post population) × (fuel conversion factor from Table 6) = tons, MCF gas, or gallons oil.

0.14 × 40,000 × 0.96 = 5,375 tons bituminous

Enter 5,375 tons in bituminous column for item *d*.

ITEM *e*. Fuel for resale may be computed as in item A knowing the type of building to be heated.

ITEM *f*. Other fuels are entered as indicated.

Table 7—Cantonment type hospital allowance

Degree-days per year	Allowance—tons std fuel per M sq ft floor area per year
0	10
500	11
1000	12
2000	16
3000	20
4000	25
5000	29
6000	33
7000	38
8000	42
9000	46
10000	50

Table 8—Hot water heating and cooking allowance

Use	Allowance—tons std. fuel per man per year		
	Coal	Gas	Oil
Hot water heating	0.30	0.25	0.30
Cooking	0.45	0.15	0.25

Table 9—Laundry allowance

Fuel used	Allowance—tons std. fuel per man per year
Coal	0.14
Gas	0.10
Oil	0.11

Table 6—Fuel conversion factors

Coal		Gas		Oil		
Btu per lb	Tons actual fuel per ton std. fuel	Btu per cu ft	M cu ft gas per ton std. fuel	A P I grav.	Btu per gallon	Gals oil per tons std. fuel
15,000	0.83	450	55.5	10	154,600	167
14,750	0.85	475	52.6	12	153,300	163
14,500	0.86	500	50.0	14	152,000	164
14,250	0.88	525	47.6	16	150,700	166
14,000	0.89	550	45.5	18	149,400	167
13,750	0.91	575	43.5	20	148,100	169
13,500	0.93	600	41.7	22	146,800	170
13,250	0.94	625	40.0	24	145,600	172
13,000	0.96	650	38.5	26	144,300	173
12,750	0.98	675	37.0	28	143,100	175
12,500	1.00	800	31.3	30	141,800	176
12,250	1.02	825	30.3	32	140,600	178
12,000	1.04	850	29.4	34	139,400	179
11,750	1.06	875	28.6	36	138,200	181
11,500	1.09	900	27.8	38	137,000	183
11,250	1.11	925	27.0	40	135,800	184
11,000	1.13	950	26.3	42	134,700	186
10,750	1.16	975	25.6	44	133,500	187
10,500	1.19	1000	25.0	46	132,400	189
10,250	1.22	1025	24.4	48	131,200	191
10,000	1.25	1050	23.8	50	130,100	192
9,750	1.28	1075	23.2			
9,500	1.32	1100	22.7			
9,250	1.35	1125	22.2			
9,000	1.39	1150	21.7			
		1175	21.3			
		1200	20.8			

HARRY CLO JOINS WPB

Harry E. Clo, a member of the Illinois Chapter of the ASHVE, is on a leave of absence from the Chicago branch of American Air Filter Co., to serve with the War Production Board, Washington, D. C. Mr. Clo will specialize in dust collecting equipment in the General Industrial Equipment Branch.

He has been an active member in the affairs of the Illinois Chapter and last year served as a member of its Meetings and Publications Committee.

FIFTY YEARS IN HEATING

The Life and Times of Warren Webster have been recorded in an interesting volume by Warren Webster, Jr., which has just been published. The book reveals much of the character and personality of the founder of Warren Webster & Co. and the part he played in pioneering the art of steam heating. Many of the incidents recorded are quoted from his reminiscences as he related them to the author, and while no attempt is made to give an exact chronological biography, the chapters not only will give the reader "a true picture of the character and personality of Warren Webster, his courtesy, kindness, unfailing humor, simplicity and fairness, of his keen judgment and vision, of the fiber and iron in the man and of the principles which entered into the structure of the institution he founded," but also a background of contemporary events during one of the greatest periods of scientific and mechanical development in history.

Many readers who knew Warren Webster will find keen enjoyment in this story of his busy life, which included many side interests. The book is dedicated by the author to the associates and friends of Warren Webster and concludes with a paraphrase of the beautiful tribute written by the late Heywood Broun, "For so many years we had the guidance and support of Warren Webster as he looked over our shoulders, that now, as we work, we feel he still looks over our shoulders."

This book is a limited edition and will be cherished by those who received copies.

Performance Characteristics of a Coal-Fired Space Heater

By R. C. Cross,* Chicago, Ill.

SUMMARY—This paper presents the results of comparative burning tests of five different fuels in a conventional coal-fired space heater. The test data provide specific information in a field where there has been a lack of such factual knowledge. The principal conclusions are that a wide variety of fuels can be burned successfully, although there is considerable variation in the results, governed largely by the reactivity of the several fuels

THE 1940 census of the United States,[1] made by the U. S. Department of Commerce, shows that 58 per cent of approximately 34 million dwelling units in the United States are heated by stoves or means other than central heating plants. These stoves and space heaters may be divided into two general classes: radiant heaters and circulating heaters. The latter type has found favor in more recent years because some heating

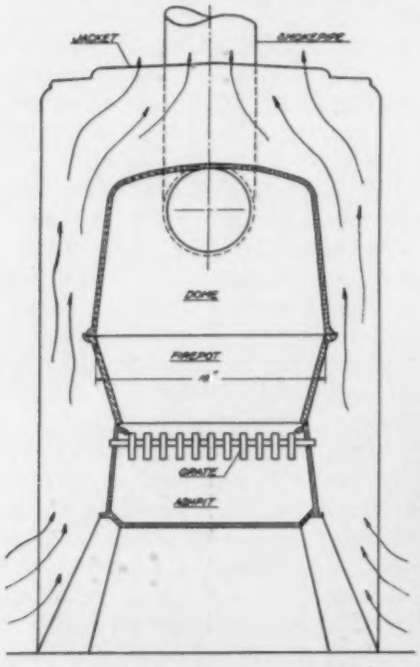


Fig. 1—Typical circulating heater

effect is obtained in rooms adjacent to the room in which the heater is located.

Circulating heaters are available with gravity and forced circulation, and special types have been developed for the various domestic fuels —gas, oil, and solid fuels. It is estimated that approximately 10 per cent of total space heater installations are gravity circulating heaters fired with solid fuels. Fig. 1 shows a typical heater of this classification.

There is a definite lack of published information and specific data in regard to the performance characteristics of this type of heater, and the test program that forms the basis of this discussion was carried out in an effort to supply some of this information.

General Program

Comparative information was obtained by determining the output of tests with anthracite, coke, lignite, coking bituminous coal, and free-burning bituminous coal. A smoke recorder also was used to obtain a log of the smoke produced with each fuel.

General Summary

The following general conclusions are derived from the test results:

1. A wide range of solid fuels can be burned successfully in the conventional space heater.
2. A considerable difference in rate of burning, available firing period, and output was found with the different fuels. These factors are dependent upon the reactivity of the fuel, all other factors remaining constant.
3. When firing high volatile fuels an excessive amount of smoke is produced by this type heater. This is an inherent disadvantage of the overfeed principle of burning.

Test Set-Up

The 18 in. heater used in these tests has 9.03 sq ft of heating surface and a grate area of 0.80 sq ft. Ratio of heating surface to grate area, 11.26 to 1.

The heater was set on scales so that the rate of burning could be determined directly by weight loss. The instruments necessary for measuring drafts and temperatures, flue gas collection and analysis, and photoelectric smoke recorder were connected in accordance with standard practice. Fig. 2 shows the general arrangement of this equipment.

Test Procedure

The data taken included the weight of fuel charged, weight of ash and refuse, ashpit draft, draft

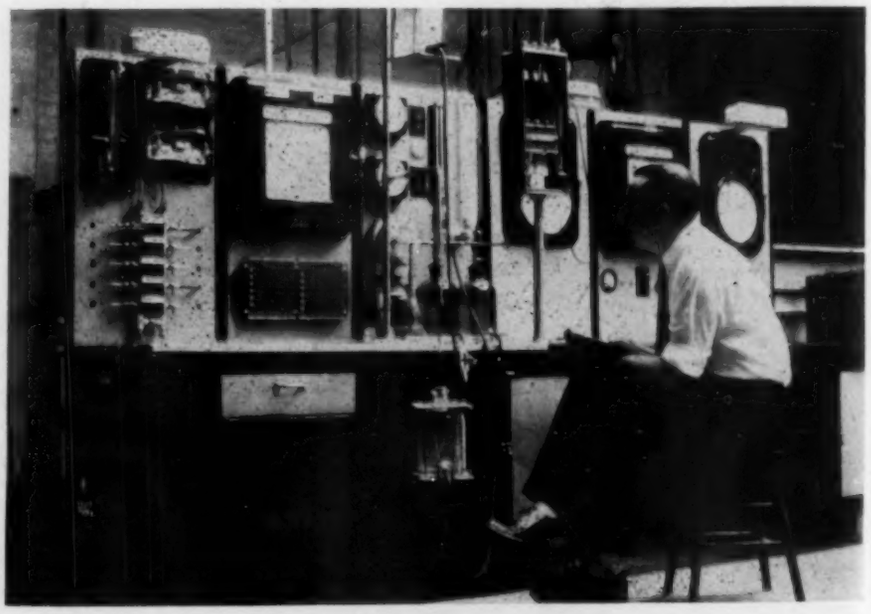


Fig. 2—Test instrument set-up

*Senior Combustion Engineer, Sears, Roebuck and Co. Member of ASHVE.

[1]Sixteenth Census of the United States, U. S. Department of Commerce.

For presentation at the 49th Annual Meeting of the American Society of Heating and Ventilating Engineers, Cincinnati, Ohio, January 1943.

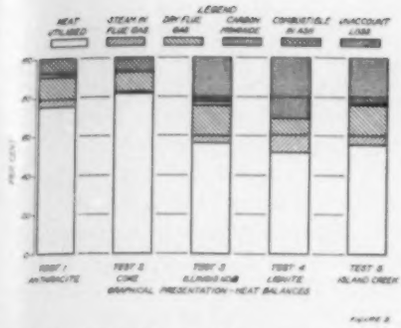


Fig. 3—Graphical diagram of heat balances

at flue gas outlet, flue gas composition, temperature of air for combustion, flue gas temperature, jacket temperature, and smoke density. In addition to logging these items, the proximate and ultimate analyses of the fuel and the combustible in the ash and refuse were determined. These data are sufficient to permit the computation of the principal losses in a conventional heat balance, namely, heat lost in steam in flue gases, heat lost in dry flue gases, heat lost in carbon monoxide, and heat lost in combustible in ash. These losses constitute the stack and grate losses. The output is expressed in Btu per hour and was obtained by subtracting the total stack and grate losses from the heat value of the coal used.

This method may be utilized in the case of anthracite and coke where unaccounted losses due to unburned hydrocarbons in the flue gases are not present. It is fair to assume an allowance for these losses in those tests where high volatile fuels are used. A value of 20 per cent was used. Data presented in several Bureau of Mines publications[2,3] indicate this to be of the correct order.

Prior to the capacity tests, a preliminary run was made to determine the region of maximum heat exchanger temperature, and a thermocouple affixed at a representative point. Thermocouples were attached to the jacket, or outer casing, on each side panel at a height midway between the grate level and the top of the heat exchanger.

A preliminary starting fire was used in all tests. During the preliminary period and the test period the ashpit damper was adjusted to provide a maximum rate of burning with the following restrictions:

(a) Maximum permissible flue gas temperature 900 F.
(b) Maximum permissible heat exchanger temperature 1000 F.
(c) Maximum permissible jacket surface temperature 400 F.

A draft of 0.02 in. water at the flue gas outlet was maintained constant in all runs. This is a representative value for the type of flue usually encountered in the field. Because the rate of burning was regulated by adjustment of the ashpit damper, however, the output is not strictly the result of the maintenance of a constant draft of 0.02 in. water. The test period was considered at an end when the flue gas temperature had dropped to 75 per cent of the value maintained during the preliminary period.

Test Results

Complete test data are shown in Table 1, and the heat balances are shown graphically in Fig. 3. The test with anthracite shows an output of 27,034 Btu per hour at 74.9 per cent over-all efficiency, the principal heat balance loss being in the dry flue gases. Fig. 4 is a graphical log of operation. It shows a stable temperature condition and reasonably constant CO_2. A slight amount of smoke, less than No. 1 Ringelmann, was found at the start of the test.

The lower reactivity of high temperature coke had a definite effect upon test results obtained with this fuel. Although a high efficiency, 81.4 per cent, was attained, the fuel burning rate and output were considerably lower than with anthracite. A short interval of smoke was recorded at the start of the test. The graphical log of this test, Fig. 5, shows a very stable flue gas temperature and CO_2.

The test with the free-burning Illinois No. 6 coal gave an output of 30,116 Btu per hour at 56.3 per cent efficiency. The burning rate was exceeded only by lignite. The principal measurable loss was the dry flue gas loss, and it will be noted that this is less than the as-

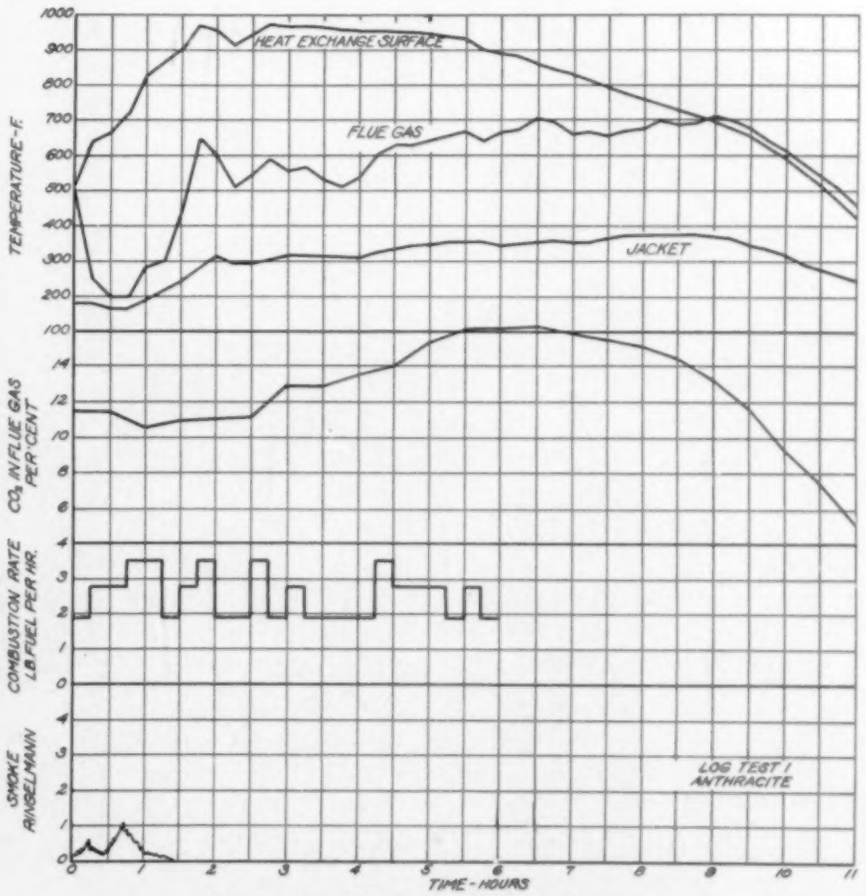


Fig. 4—Graphical log of anthracite test

[2]Heat Transference and Combustion Tests in a Small Domestic Boiler, by John Blizard, W. M. Myler, Jr., J. K. Seabright and C. P. Yaglogiou. (ASHVE Transactions, Vol. 29, 1923.)

[3]Heat Transference and Combustion Tests in a Small Domestic Boiler, by H. W. Brooks, M. L. Orr, W. M. Myler, Jr., and C. A. Herbert. (ASHVE Transactions, Vol. 31, 1925.)

sumed 20 per cent unaccounted loss. Fig. 6 shows the erratic flue gas temperature caused by changes in fuel bed condition, ignition of the over-fire gases, and manual attention. A similar trend is found in the CO_2 record.

Very bad smoke was produced in this test, No. 5 Ringelmann density persisting for over 30 min at the start. The smoke greatly exceeded permissible values established by municipal smoke ordinances.

The principal characteristics of the lignite test are the high rate of combustion, and the high losses due to carbon monoxide in the flue gases, and the steam in the flue gases. The lignite used in this test had been in storage for several months and analysis showed 17.9 per cent moisture as compared to 37 per cent, as mined.

The over-all efficiency was only 51.4 per cent, but because of a much higher rate of burning than with the other fuels, the output was greater. The test log with lignite, shown in Fig. 7, shows a period of approximately 45 min of No. 5 Ringelmann smoke at the start of the test.

The test run with a coking bituminous coal, Island Creek, gave an output of 24,673 Btu per hour at 55.2 per cent efficiency. The similarity in the heat balances for this fuel and the Illinois No. 6 coal is noted. The lower output for the Island Creek coal is principally due to the lower burning rate. Fig. 8 shows the graphical log for this fuel. The smoke produced in this test was the greatest of all the fuels.

A general review of the data shows that good combustion was obtained with all fuels except the lig-

Table 1—Test data

General Information										
1. Number of test	1		2		3		4		5	
2. Date of test	7-9-42		7-16-42		7-22-42		7-30-42		8-4-42	
3. Length of test-hour	11.0		12.5		6.0		4.0		8.0	
Heater Data										
4. Heating surface—sq ft					9.03					
5. Grate area—sq ft					0.80					
6. Ratio heating surface to grate area					11.26:1					
Fuel										
7. Kind	Anthracite		Coke		Bituminous		Lignite		Bituminous	
8. Seam or Type	#6, D, L, & W.		Solvay		Illinois No. 6		Velva, N. D.		Island Creek	
9. Size	Nut		Nut		2 in. x 3 in.		2 in. x 4 in.		2 in. x 3 in.	
Proximate analysis, as fired, per cent										
10. Moisture	1.5		3.5		8.2		17.9		1.8	
11. Volatile matter	4.1		1.2		33.9		35.3		38.1	
12. Fixed carbon	83.6		88.3		50.5		41.2		55.5	
13. Ash	10.8		7.0		7.4		5.6		4.6	
14. Calorific value, Btu per lb	12,880.0		12,850.0		12,235.0		8,952.0		14,190.0	
Ultimate analysis, as fired, per cent										
15. Carbon	76.6		87.7		68.5		37.6		79.6	
16. Hydrogen	4.1		0.8		3.6		7.1		5.6	
17. Oxygen	6.0		2.2		17.8		48.6		7.7	
18. Nitrogen	1.5		1.3		1.6		0.6		1.3	
19. Sulphur	1.0		1.0		1.1		0.5		1.2	
20. Ash	10.8		7.0		7.4		5.6		4.6	
Weights—pounds										
21. Total weight loss	27.5		16.25		24.25		29.25		24.0	
22. Equivalent fuel burned	30.85		17.45		26.20		30.85		25.2	
Ash and refuse										
23. Weight of ash and refuse—lb	5.6		2.5		1.25		0.50		2.0	
24. Combustible in ash and refuse—per cent	40.5		51.2		50.0		0.0		42.5	
25 Carbon burned per lb fuel fired—lb	0.69		0.80		0.66		0.38		0.76	
Drafts—inches water										
26. Ashpit	0.010		0.020		0.018		0.020		0.018	
27. Flue gas outlet	0.019		0.021		0.021		0.020		0.020	
Flue gas composition, per cent										
28. Carbon dioxide (CO_2)	13.4		9.5		11.2		11.5		11.1	
29. Oxygen (O_2)	6.1		11.5		7.7		5.5		7.5	
30. Carbon monoxide (CO)	0.5		0.0		0.5		3.9		0.1	
31. Nitrogen (N_2) (by difference)	80.0		79.0		80.6		81.1		81.3	
32. Dry flue gas per lb of fuel, lb	12.6		21.0		14.2		6.2		17.5	
33. Excess air, per cent	38.3		123.0		56.6		20.2		53.1	
Temperatures—F										
34. Air for combustion	84.0		89.0		89.0		87.0		87.0	
35. Flue gases	572.0		345.0		645.0		605.0		628.0	
Hourly rates										
36. Fuel burned—lb per hour	2.8		1.39		4.37		7.71		3.15	
37. Fuel burned—lb per sq ft grate per hour	3.5		1.74		5.46		9.63		3.94	
38. Heat release rate—Btu per hour	36,064.		17,861.		53,367.		69,019.		44,698.	
Heat Balance	Btu	Per cent	Btu	Per cent	Btu	Per cent	Btu	Per cent	Btu	Per cent
39. Heat lost in steam in flue gases	471	3.7	83	0.6	424	3.5	816	9.1	648	4.6
40. Heat lost in dry flue gases	1480	11.5	1290	10.0	1894	15.5	772	8.6	2270	16.0
41. Heat lost in carbon monoxide	252	2.0	0	0.0	286	2.3	977	10.9	69	0.5
42. Heat lost in combustible in ash	1022	7.9	1022	8.0	292	2.4	0	0.0	526	3.7
43. Total measurable losses	3225	25.1	2395	18.6	2896	23.7	2565	28.6	3513	24.8
44. Unaccounted losses (assumed)	0	0.0	0	0.0	2447	20.0	1790	20.0	2836	20.0
45. Calorific value of fuel	12,880	100.0	12,850	100.0	12,235	100.0	8952	100.0	14,190	100.0
46. Heat utilized, efficiency	9655	74.9	10,455	81.4	6892	56.3	4597	51.4	7841	55.2
Output										
47. Output—Btu per hour	27,034		14,539		30,116		35,476		24,673	
48. Heat transfer rate—Btu per sq ft per hour	2995		1610		3335		3930		2735	
Smoke										
49. Average concentration	0		0.5		—		—		—	
50. Average Ringelmann number	0		1—		1+		1+		1+	
51. Average min. per hour No. 1 Ringelmann, or greater	0		2		15		16		32	
52. Average min. per hour No. 2 Ringelmann, or greater	0		1		14		15		16	
53. Average min. per hour No. 3 Ringelmann, or greater	0		0		12		14		13	
54. Average min. per hour No. 4 Ringelmann, or greater	0		0		11		14		11	
55. Average min. per hour No. 5 Ringelmann	0		0		9		6		10	

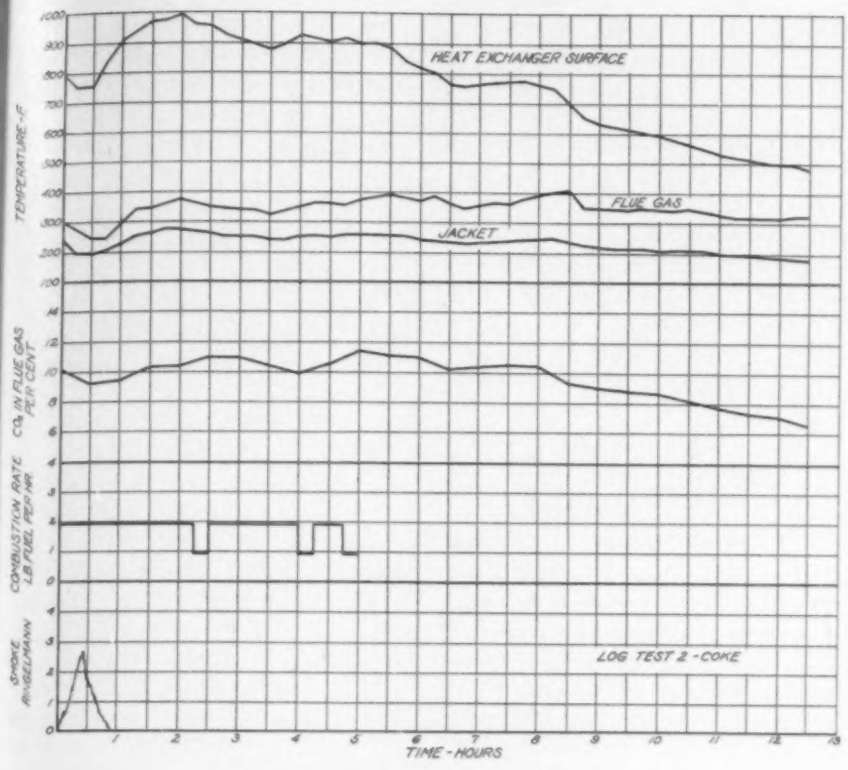


Fig. 5—Graphical log of coke test

nite, where high *CO* was found.

Referring to the temperature limitation values established, it is shown that the permissible rate of output was governed largely by the heat-exchanger limitation of 1000 F, and the maximum jacket temperature of 400 F. A limiting flue-gas temperature of 900 F was attained only in the test with Island Creek coal.

This series of tests offers evidence confirming the belief that capacities obtained with anthracite are fairly applicable to those for bituminous coals. Excepting coke and lignite, following output relationships were found:

Anthracite	100 (unity)
Bituminous (free burning)	111
Bituminous (coking)	91
Average variation from unity	10.0 per cent

The formation of dense smoke for long periods of time when firing high volatile fuels emphasizes the need for the development of improved types of heaters that will be free from this defect. At the present time much attention is being given to this problem by Battelle Memorial Institute and others.

Tentative Rating Method

Inasmuch as the heater used was fairly representative of its type, and the data are comprehensive, the following method of rating was evolved from the anthracite test. It is understood that this is a suggested method *only*, and confirming evidence from additional tests by other laboratories would be most helpful in evaluating the method.

The method is based upon a formula similar to that promulgated by The National Warm Air Heating and Air Conditioning Association[4] in which the several physical dimensions and relationships of a warm air furnace are employed.

[4]The Standard Gravity Code, National Warm Air Heating and Air Conditioning Association.

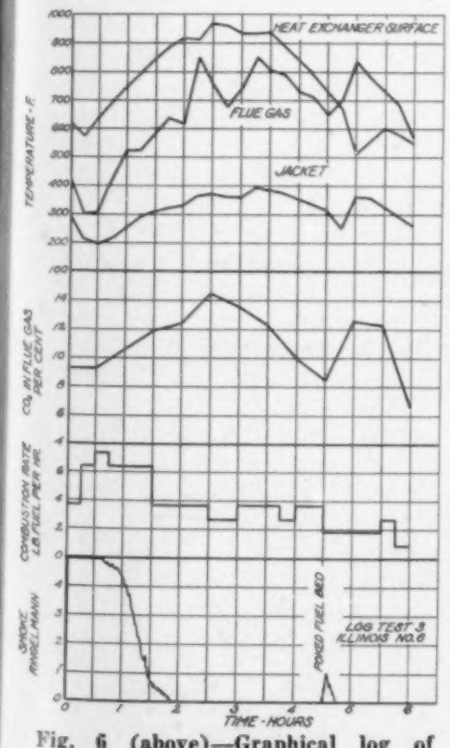
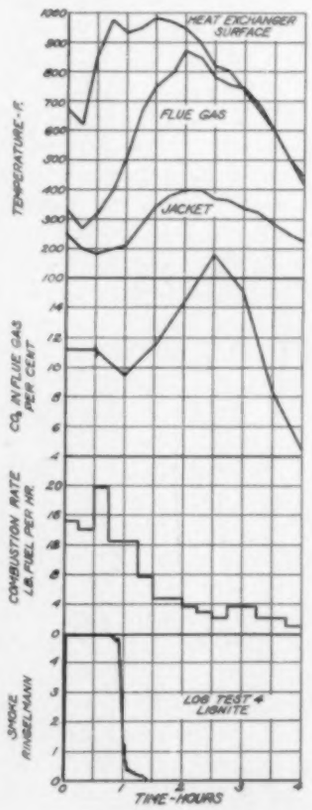


Fig. 6 (above)—Graphical log of Illinois No. 6

Fig. 7 (right)—Graphical log of lignite test



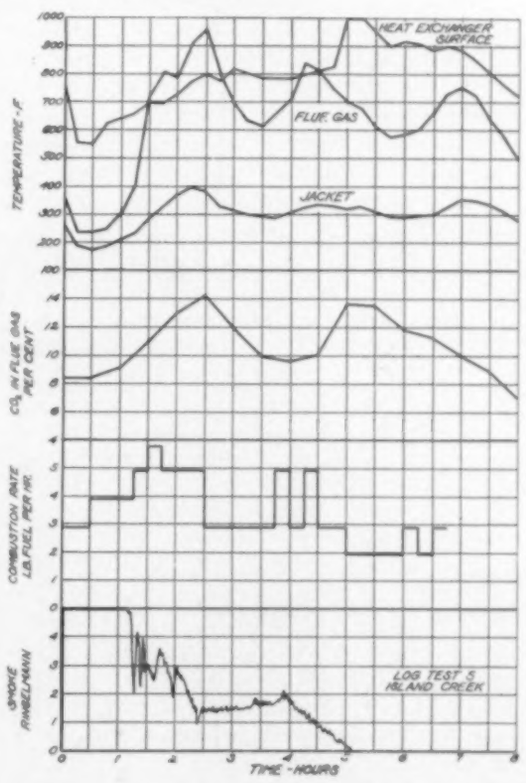


Fig. 8—Graphical log of Island Creek coal

A study of the ratio of heating surface to grate area of a number of typical gravity circulating heaters for solid-fuel firing showed a mean ratio of 16:1. This value is used in the basic formula:

$$\text{Output} = 4 \times 12{,}500 \times 0.75 \times \frac{G}{144} [1 + 0.02\ (R - 16)]$$
$$= 260 \times G\ [1 + 0.02\ (R - 16)]$$

Where

Output = Btu per hour
G = Grate area, square inches.
R = Ratio heating surface to grate area

This equation is based on a combustion rate of 4 lb coal per square foot grate per hour, calorific value of fuel 12,500 Btu per pound as fired, and an over-all efficiency of 75 per cent. A 2 per cent allowance is made for each unit above or below the basic 16:1 ratio of heating surface to grate area. Applying the proposed rating formula to the heater used in the test program, the following data are obtained:

$$\text{Output (Btu per hour)} = 260 \times 115.2\ [1+0.02\ (11.26 - 16)] = 27{,}256$$

This is compared to the output obtained by test with anthracite, which was 27,034 Btu per hour.

It is understood that the output obtained by the above method is a *gross output*. In order to provide a proper pickup and overload factor, the maximum Btu per hour loss of the heated space should not exceed 80 per cent of the gross output.

Conclusions

The material in this discussion has been presented as an interesting example of the comparative performance of a specific heating device when fired with a wide variety of solid fuels. It is hoped that it has served a useful purpose in throwing some light upon a field in which little technical information is generally available.

FOUNDRY WAR PRODUCTION CONGRESS

The American Foundrymen's Association will hold its 47th annual meeting in St. Louis, April 28-30, 1943, which will be a mobilization of management, technical and operating men, for the purpose of devising ways and means for extending the use of cast metals in the war effort. During World War I, the AFA staged five successful conventions, each with increasing interest and attendance.

In July 1941 the Board of Directors planned for a Foundry Congress and Exhibit in 1942, emphasizing the importance of the castings industry in defense work. Later the plan was broadened to include the first Western Hemisphere Foundry Congress as a step toward furthering the government's good neighbor policies, hemisphere solidarity, and the further purpose of a united effort on the part of the foundry industries in all the Americas. The attack on Pearl Harbor December 7, and the declaration of war with axis powers changed the program to an *All Out* effort of the foundry industry for increased production of war materials.

The second World War II Foundry Congress, which will be held without commercial exhibits, will be another *All Out* effort to strengthen and increase the foundry industry's contribution to complete victory. The St. Louis Chapter of AFA will be host to the foundrymen of America, with Hotels Jefferson and Statler as the joint headquarters for meetings, with registration at the Hotel Jefferson.

ASRE ELECTS OFFICERS

At the 38th annual meeting of the American Society of Refrigerating Engineers, held in New York, December 1 and 2, the following officers were elected to serve for the ensuing year: President, C. R. Logan, Pittsburgh, Pa.; vice-presidents, A. B. Stickney, Chicago, Ill., and J. F. Stone, New York, N. Y.; treasurer, J. J. Bergdoll, Jr., York, Pa.; directors, C. S. Leopold, Philadelphia, Pa.; L. C. Leslie, Philadelphia, Pa.; Nels Rosberg, Los Angeles, Calif.; A. B. Schellenberg, St. Louis, Mo.; and J. M. Tucker, Knoxville, Tenn. The directors were elected to serve for a three-year term.

The newly elected officers were inducted into office on December 2, at the closing session of the meeting at the Hotel Commodore, at which the essentiality of refrigeration in war production was emphasized in the technical program.

E. B. ROYER DIES AT 54

Earl B. Royer, construction engineer with Fosdick and Hilmer Co., died November 30, 1942, at the Veterans' Hospital, Dayton, Ohio, after an illness of one year. Although born in Nashville, Tenn., April 4, 1888, he lived in Cincinnati for over 50 years.

He received his M.E. degree from the University of Cincinnati in 1912, and his early training in draughting and designing was received in the employ of Walter G. Franz, consulting engineer in Cincinnati. With Fosdick and Hilmer, successors of Walter G. Franz, he was a designing, superintending and testing engineer. He designed the heating, ventilating, electrical and sanitary equipment for numerous buildings, including the Hotel Gibson and Longview Hospital, Cincinnati; the Chemistry Building at the University of Cincinnati; Neil House, Columbus; Ogden Hall at Miami University, Oxford, Ohio; Forest Theater in Cincinnati; Norwood F. and A. M. Lodge, Norwood, Ohio, and the steam transmission systems for the Western College for Women, Oxford, Ohio.

Mr. Royer served on the Board of Governors of the Cincinnati Chapter of the ASHVE from 1932-37, as secretary-treasurer in 1934, as vice-president in 1935, and as president of the Chapter in 1936. As one of the active members of the Chapter, he will be greatly missed by his many friends and colleagues in the Society. Besides being a member of the ASHVE, which he joined in 1928, he was a member of the Norwood Lodge 576, F. and A. M., and was an elder in Montgomery Road Church of Christ.

He is survived by a son, James H. Royer, and a sister, Mrs. Lucille Strietmann, both of Cincinnati, to whom the Officers and Council of the Society extend their sincere and heartfelt sympathy.

Funeral services for Mr. Royer were held at the Jacocks funeral home and burial was in Spring Grove Cemetery.

Cincinnati Is Ready for the 49th Annual Meeting

January 25-27, 1943
Hotel Gibson

American Society of Heating and Ventilating Engineers

Cincinnati skyline at night

PREPARATIONS HAVE been completed for the Society's 49th Annual Meeting at the Hotel Gibson, Cincinnati, Ohio, January 25-27, according to Chairman Buenger of the Arrangements Committee. Members of the Society are invited to participate and are advised to make their plans well in advance.

The subjects prepared for discussion are of special interest as the majority of papers selected by the Meetings Committee have a definite bearing on the war program. A wide variety of topics have been included and they should have a special appeal to members engaged in war production work, as several report research results that are of vital significance at this time.

Details of the program are given on a following page, and it should be noted that the papers cover a discussion of naval vessel ventilation, food preservation by dehydration methods, the performance of insulating materials, the Army's coal supply, fuel economy with reduced night temperatures, and the effect of hot atmosphere on efficiency.

One part of the Tuesday afternoon session will be featured by a panel discussion on the subject of Keeping Fit in Cold Houses. This will be conducted by Prof. C.-E. A. Winslow, New Haven, Conn., and among those who have agreed to participate are Dr. C. A. Mills of the University of Cincinnati, Mrs. Ivah E. Deering, of Cincinnati, and Wallace Waterfall, Chicago. The discussion will bring out those phases of the subject with which the physiologist, the physician, the housewife, the insulating engineer, and the housing manager must deal.

On January 24 there will be a number of preliminary committee meetings and the Chapter Delegates are scheduled to meet in the evening. The members of the local chapter have arranged a reception and a variety movie program for those who do not have committee functions.

Cincinnati Chapter members have made a special effort to provide an attractive program for the leisure hours. Monday night there will be a dinner and ice show at the Netherland Plaza Hotel and Tuesday the annual banquet and dance will be held at the Hotel Gibson, with a speaker of national reputation.

Every member who can should attend this meeting, as it provides a forum for the exchange of vital ideas, and the program is streamlined for wartime economy of time and money.

Your hosts say, "Welcome to Cincinnati—the Queen City—January 25-27."

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the Journal of the Society at least twice during every year, preferably just prior to each meeting.

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary

5—That the grouping of features and the sale of tickets for group features be discouraged.

6—That the raising of funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter or local members be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

Adopted at Council Meeting, January 29, 1926.

W. C. Green

Albert Buenger

A. L. Hard

Capt. C. E. Hust

A. W. Edwards

G. B. Houliston

COMMITTEE ON ARRANGEMENTS

Cincinnati Chapter

W. C. Green, *Honorary Chairman*

Albert Buenger, *General Chairman*
A. L. Hard, *Vice-Chairman*

Banquet: I. B. Helburn, *Chairman*
Entertainment: G. B. Houliston, *Chairman*
Finance: W. H. Junker, *Chairman*
Inspection Trips: M. E. Mathewson, *Chairman*
Ladies: Mrs. G. B. Houliston, *Chairman*
Publicity: K. A. Wright, *Chairman*
Reception: H. E. Sproull, *Chairman*
Transportation: A. W. Edwards, *Chairman*

Chapter Officers

Capt. Carl E. Hust, *Honorary President*

A. L. Hard, *President*
Albert Buenger, *Vice-President*

G. V. Sutfin
Secretary-Treasurer

W. H. Junker and E. J. Richard
Board of Governors

H. E. Sproull

W. H. Junker

M. E. Mathewson

K. A. Wright

E. J. Richard

G. V. Sutfin

PROGRAM

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

January 25-27, 1943

Hotel Gibson
Cincinnati, Ohio

Aerial view of Cincinnati Art Museum

Sunday—January 24

10:00 a. m. Registration (Foyer, Grand Ballroom)
10:00 a. m. Meeting Committee on Research (Parlor E)
2:00 p. m. Council Meeting (Parlor H)
2:30 p. m. Motion Pictures
6:30 p. m. Past Presidents' Dinner (Parlor G)
7:30 p. m. Chapter Delegates' Conference (Parlor H)

Monday—January 25

9:00 a. m. Registration (Foyer, Grand Ballroom)
9:30 a. m. TECHNICAL SESSION (Ballroom)
- Reports of Officers and Committees
- Warship Ventilating, Heating and Air Conditioning, by Lt.-Comdr. T. H. Urdahl and W. C. Whittlesey
- Some Engineering Problems of the New Vegetable Dehydration Industry, by W. B. Van Arsdel
- Performance of Side Outlets on Horizontal Ducts, by D. W. Nelson and G. E. Smedberg
- Amendments to Constitution and By-Laws
- Report of Tellers of Election

12:15 p. m. Ladies Luncheon and Style Show—Shillito & Co.
12:15 p. m. Get-together Luncheon (Ballroom, Hotel Gibson)
- *Speaker*—Dr. B. M. Woods, University of California.
- *Subject*—The Man-power Problem in Engineering
- *Toastmaster*—Fred F. McMinn, President, Engineer Club of Cincinnati

2:00 p. m. TECHNICAL SESSION (Ballroom)
- Army Fuel Consumption Studies of 1941-42, by Major L. C. McCabe, S. Konzo and R. E. Biller
- Performance Characteristics of a Coal-Fired Space Heater, by R. C. Cross
- Operation of the Research Home with Reduced Room Temperatures at Night, by A. P. Kratz, W. S. Harris and M. K. Fahnestock

6:30 p. m. Dinner and Ice Show—Netherland Plaza Hotel

Tuesday—January 26

9:00 a. m. Registration
9:30 a. m. TECHNICAL SESSION (Ballroom)
- Comparative Resistance to Vapor Transmission of Various Building Materials, by L. V. Teesdale
- Summer Comfort Factors as Influenced by the Thermal Properties of Building Materials, by C. O. Mackey and L. T. Wright, Jr.
- The Effect of Convection in Ceiling Insulation, by G. B. Wilkes and L. R. Vianey
- Friction Heads Due to Water Flow in Copper, Brass and Other Smooth Pipes, by F. E. Giesecke

2:00 p. m. Ladies Dessert Bridge
2:00 p. m. TECHNICAL SESSION (Ballroom)
- Physiological Reactions Applicable to Workers in Hot Industry, by Lt.-Comdr. F. C. Houghten, Carl Gutberlet and M. B. Ferderber.
- Panel Discussion—How to Keep Fit in Cold Homes, conducted by Dr. C.-E. A. Winslow

7:00 p. m. ANNUAL BANQUET (Roof Garden, Hotel Gibson)
- Installation of New Officers and Presentation of Past President's Emblem to E. O. Eastwood
- Music by Jimmy Wilbur

Wednesday—January 27

9:00 a. m. Organization Meeting of Council (Parlor H)

ASHVE Members

Cincinnati

Members on Active Duty*

U. S. ARMY

BACHOFER, Henry A., Jr., Pvt., 87th Air Base Squadron.
BADGETT, W. Howard, Capt., 360th Infantry School.
BARNES, Hugh S., Capt., 99th C.A. (aa).
BERNARD, Edgar L., Lieut., 23rd Armored Engr. Bn.
BERZELIUS, Carl E., Capt., Bn. Comdr.
BROWN, Harper J., First Lieut., Ordnance Dept.
BRUNDAGE, F. Ward, First Lieut., 423rd C.A.
BUCKLEY, D. J., Second Lieut., Air Corps.
BURNS, Frank G., Capt., Infantry.
CAMPBELL, Alfred Q., Jr., Lieut., F.A.
CAMPBELL, George W., Capt., Air Corps.
CASKEY, Luther H., Jr., First Lieut., Co. F., 38th Engrs.
CHAPIN, Harvey G., First Lieut., Air Corps.
CHASE, R. E., Jr., Pvt. F/Cl, 417th Ordnance Dept., A.V.N.
CHEESEMAN, Evans W., Capt., Personnel Officer.
CLARK, Albert C., Capt., A.P.O. 843, Seattle, Wash.
CLEMENS, Joseph D., Second Lieut. (Engrs.) Air Corps.
CLOW, Sherwood A., Second Lieut., Signal Corps.
COX, V. G., Major, C. A.
CRAWFORD, Arthur C., Capt., Q.M.C.
CROLEY, Jack G., First Lieut., 76th C.A.
CROPPER, Robert O., First Lieut., Q.M.C.
DABBS, John T., First Lieut., C.A.C.
DANIELSON, Wilmot A., Brig-Gen. Q. M.C.
DICKSON, Robert W., Jr., Lieut., 40th Bombardment Group.
DRUM, Leo J., Jr., Second Lieut., (Hdqtrs. Special Troops—2686).
ESCHENBACH, Sam P., First Lieut., 62nd C.A. (aa).
FELDSTEIN, Harold, Capt., Ordnance Dept.
FINERAN, Edward V., First Lieut., Signal Corps School.
FLARSHEIM, C. A., Pvt., E.R.C., Air Corps.
FORDERBRUGGEN, Kevin J., Major, 65th C.A. (aa).
FOSTER, John G., Lieut, Air Corps.
FRANKLIN, S. H., Jr., Major, Ordnance Dept.
FREEMAN, Alfred W., Second Lieut., Air Corps.
FRIEDMAN, D. Harry, Capt., Post Engr.
GAULT, George W., Lieut., Corps of Engrs.
GONZALEZ, Rafael A., Capt., Ordnance Dept.
GRABMAN, Henry B., Lieut., 36th Engineers (c).
GREEN, Everett W., Pvt., 87th Bn.
HAWES, Harold D., Master Sgt., A.A. A., O.C.S. Batry. I, 2nd Plat.
HENDRICKSON, W. B., Staff Sgt., Air Corps Technical School.
HERBERT, Richard M., Lieut., Air Corps.
HOLMES, Richard E., First Lieut., Ordnance Dept.
HUBBUCH, N. J., Student, Communications Div.. Air Corps.
HUST, Carl E., Capt., Ordnance Dept.
HUTCHINSON, S. Lee, Jr., Second Lieut., Air Corps (Engrg. Officer).
IBISON, James L., First Lieut., Asst. Constructing Quartermaster.
JONES, James T., Second Lieut., Engineer Reserve Corps.
KELLY, Olin A., Aviation Cadet, Air Corps.
KILLOREN, Donald E., Hdqs. Co., 15th Infantry.
KUMMER, Calvin J., First Lieut., 72nd F.A.
KURTZ, Robert W., Capt., Ordnance Works.
LENONE, J. M., Major, Corps of Engrs.
LIGHT, John C., Capt., Ordnance Dept.
LLOYD, Edmund H., First Lieut., Office, Chief of Engrs.
MACEACHIN, Grahm C., Capt., Corps of Engrs.
MACGREGOR, Cecil M., Capt., F.A.
MALIN, Benjamin S., First Lieut., Ordnance Dept.
MARINO, Frank A., Tech. Sgt. (overseas).
MARSHALL, Thomas A., Lieut., Tech. Div. V., Engr. Board.
MARSTON, Anson D., Major, G.S.C.
MCCAIN, H. King, Lieut., Quartermaster School.
MCDERMOTT, John P., Corps of Engrs.
MCKAY, Albert W., First Lieut., Ordnance Dept.
MORAWECK, Alvin H., Jr., Lieut.
MORTON, Harold S., Major, Ordnance Dept.
NEAL, James P., Capt., Ordnance Dept.
NORRINGTON, Walter L., First Lieut., Ordnance Dept.
OTTS, John G., First Lieut., Ordnance Dept.
PARKER, R. A., First Lieut., 749th M. P. Det.
PARSONS, Leonard D., Jr., Capt., Post Engr.
PEISER, Maurice B., Aviation Cadet.
PELLMOUNTER, T. V., Second Lieut., 55th Ordnance Co.
PRAWL, Frank E., Capt., Ordnance Dept.
REIF, Allan F., Col., 74th Infantry.
RHINE, George R., Capt., Ordnance Dept.
ROSSITER, I. J., Lieut., F.A.
ROTHMAN, S. N., Capt., Occupational Hygiene Div.
RUEMMELE, Albert M., First Lieut., Ordnance Section PRGD.
SANDFORT, John F., First Lieut., F.A., B.O.C. No. 44.
SATTERLEE, Harry A., Second Lieut., Ordnance Dept.
SAURWEIN, G. K., Major, Ordnance.
SCHLICK, Paul F., Colonel, 216th C.A.
SCHROEDER, William R., Pvt., Q.M.C.
SCOTT, Allison F. H., Lieut. Colonel, Coast Artillery Corps.
SHARP, John R., Major, Corps of Engrs.
SHEARER, William A., Jr., Second Lieut., Corps of Engrs.
SLOANE, David J., 56th General Hospital.
SNYDER, Edwin F., Jr., Second Lieut., Corps of Engrs.
SOBEL, Frank, Pvt., Co. A, 101 M.P. Bn.
SPENCE, Robert A., Lieut., Ordnance Dept.
STERNER, Douglas S., First Lieut., 282nd, Q.M.C.
STEVENS, Kenneth M., First Lieut., 958th C.A.
TRAYNOR, H. S., Lieut., Corps of Engrs.
VANNOUHUYS, Herbert C., First Lieut., Signal Corps.
WEATHERBY, E. P., Jr., Second Lieut., Aviation, 8th Fighter Command.
WEAVER, J. v. O., Lieut.-Col., Air Corps.
WERNER, Philip, Reserve Officer, Signal Corps.
WILSON, Westray E., Major, Q.M.C.
ZINK, David D., Major, G.S.C., 1st Arm'd Corps.

U. S. NAVY

AKERS, George W., Lieut.-Comdr., U.S.S. Markab.
ASH, R. S., Ensign, U.S.N.R.
BABER, John E., Ensign, U. S. Navy Recruiting Station.
BAKER, Roland H., Lieut.-Comdr., U.S.N.R.
CARTER, J. H., Lieut. (sg).
CARY, Edward B., Comdr. (CEC), U. S.N.R.
CHAPMAN, William A., Jr., Lieut., U.S.N.R.
COVER, R. R., Warrant Officer, EV (s), U.S.N.R.
DAVIDSON, John C., Lieut. (jg), U.S. N.R.
EUTSLER, Eugene R., Jr., Lieut. (jg), U.S.N.R.
EVERETTS, John, Jr., Lieut. O-V (P), U.S.N.R.
FLORETH, John J., Lieut., U.S.N.R.
GREGG, Stephen L., Lieut., U.S.N.R.
HERO, George A., Jr., Lieut-Comdr., U.S.N.R.
HERRE, Harold A., Ensign, E.V.S., U. S.N.R.
HERTZLER, John R., Lieut., U.S.N.R.
HOUGHTEN, F. C., Lieut.-Comdr., U.S. N.R.
JORDY, J. J., Lieut. (sg).
KAHN, Charles R., Jr., Lieut. (jg), U.S.N.R.
KOLB, Robert P., Lieut.-Comdr., U.S. N.R.
LADD, David, Lieut.-Comdr., U.S.N.R.
LANDAUER, Leo L., Lieut. (CEC), U. S.N.R.
LEVINE, Lawrence J., Ensign, U.S. N. R.
LIEBLICH, Murray, Ensign, U.S.N.R.
MABLEY, Louis C., Lieut.-Comdr., U.S. N.R.
MATHEKA, Charles R., U.S.S. Tattnall.
MATTHIES, Leo A., Ensign, U.S.N.R.
MILLARD, Junius W., Lieut. (sg), Organized Reserve.
MORSE, Louis S., Jr., Lieut. (jg), U.S. N.R.
MULCEY, Paul A., Lieut. (sg), U.S. N.R.
PAETZ, G. A., Ensign, U.S.N.R.
PARKINSON, John S., Lieut., U.S.N.R.
POWERS, Edgar C., Lieut. (jg), U.S. N.R.
QUEER, E. R., Lieut. (jg), U.S.N.R.
RILEY, John N., Lieut. (jg) E-V (s), U.S.N.R.
RODEE, E. J., Lieut., U.S.N.R.
ROGERS, Charles S., Lieut. (jg), U.S. N.R.
SCHECHTER, Jack E., Lieut. (jg), Naval Training School.
SHAPIRO, Charles A., Ensign, D-V (s), U.S.N.R.
SIMPSON, Robert L., Lieut. (jg), U.S. N.R.
STACEY, Alfred E., Jr., Comdr., U.S. N.R.
STEEL, R. Justin, Lieut. (jg), U.S. N.R.
STERNE, C. M., Lieut.-Comdr., U.S. N.R.
TIMMIS, W. W., Lieut.-Comdr., U.S. N.R.
TURNER, John P., Jr., Lieut. (jg), U.S.N.R.
URDAHL, Thomas H., Lieut.-Comdr. (E-V) (s).

*Compiled as of December 15, 1942.

WATT, Richard M., Jr., Capt.
WESTPHAL, N. E., Ensign, U.S.N.R.
YOUNGER, John R., U. S. Naval Training School.
ZUROW, William A., Ensign, U.S.N.R.

FOREIGN MEMBERS

ARMOUR, Edson G., Royal Canadian Air Force.
BALLANTYNE, George L., Instructor, Royal Canadian Air Force.
BARNETT, Campbell M., Canadian Active Service Forces.
BISHOP, Joseph W., Canadian Active Service Forces.
BODMER, Emmanuel, Lieut., Air Force.
BOWERMAN, E. L., Flying Officer, Royal Canadian Air Force.
BUTT, Roderick E. W.
DANIEL, William E., Second Lieut., Royal Artillery.
DOWLER, Edward A., First Lieut., Royal Canadian Engineers.
FOSTER, Philip H., Pilot Officer, Royal Canadian Air Force.
FOX, John H., Major, Ordnance Co.
JOHNS, Charles F., Flight Lieut., Royal Canadian Air Force.
KITCHEN, William H., Lieut. (S.B.), Royal Canadian Naval Volunteer Reserves.
LABONNE, Henri, Lieut., "Les Fusiliers de Sherbrooke."
MACLACHLAN, Victor D., Flight Lieut., Royal Air Force Volunteer Reserves.
NORFOLK, Leslie W., Major, Royal Engrs.
PENNOCK, William B., Major, Royal Canadian Engrs.
POUGHER, Bernard R. E., Sergt., 110 (el) A. T. Coy R. E.
PRICE, Ernest H., Lieut., Royal Canadian Engrs.
PRYKE, John K. M., Capt., Royal Army Ordnance Corp.
RICHARDSON, Robert D., Bombardier, Royal Regiment Artillery.
ROBINSON, Jack A.
SMITH, Gerald E., Royal Canadian Engrs.
VEGLERY, Alexander.
WILKINSON, Arthur, Flight Lieut. Royal Canadian Air Force.
WOOD, Alfred W., Royal Canadian Air Force.

HOUSING AND FUEL OIL CONVERSIONS RECOMMENDED

Conversion of existing structures to provide additional war housing units and conservation of scarce fuel oil supplies through fuel saving installations represent two methods by which American home owners can lend important assistance to the war effort during coming months, Federal Housing Commissioner A. H. Ferguson recently declared.

With wartime needs having cut sharply into available supplies of heating oil, it is all the more imperative that home owners still using fuel oil convert their heating equipment at once to permit the use of coal, Mr. Ferguson asserted. If such conversion is not possible, the home owner should act immediately to reduce his fuel needs by installing insulation, weatherstripping, or storm windows and doors, the Commissioner said.

Such operations can be carried out quickly and at relatively little expense, the Commissioner pointed out.

In order to facilitate fuel saving measures of this type, the War Production Board recently extended until January 1, 1944, its exemption of them from Conservation Order L-41. The exemption applies to the conversion or substitution of heating equipment to permit the use of fuel other than oil, electricity and gas, and to the installation of insulation materials, air cell pipe coverings, weatherstripping, and storm windows and doors. The exemption means that such work may be undertaken without the specific WPB authorization generally required under Order L-41.

If the home owner lacks ready funds to pay for such improvements, financing is available under the FHA's Title I plan from private lending institutions in all sections of the country, Mr. Ferguson said. Title I loans for these purposes may run for as long as three years, to be repaid in equal monthly installments.

In another important wartime field open to American home owners, the remodeling or conversion of existing dwellings and structures to provide additional living quarters for war workers and their families in the critical war housing areas affords property owners an opportunity to participate in the war housing program on a remunerative basis, Mr. Ferguson stated.

The National Housing Agency, of which the FHA is one of the constituent units, is strongly encouraging such operations as an important segment of its program to meet the urgent war housing need. The NHA program embraces both privately financed conversion and the leasing of private houses and buildings by the Government for conversion into additional units.

In the field of privately financed conversion, the FHA offers a special Title I financing plan permitting loans of up to $5000 which may be repaid over a period of as long as seven years. Conversion or remodeling projects financed by such loans must be located in the designated critical war housing areas and the additional accommodations produced must be rented to eligible war workers.

Evidence of increasing activity in privately financed conversion is given by the recent trend of applications for WPB priorities assistance for such projects. During the seven months ended November 30, the WPB approved preference rating orders for private conversion projects providing 30,000 dwelling units for war workers. Applications for such orders are filed with FHA field offices.

The National Housing Agency recently announced that the WPB soon will grant AA-4 preference ratings to privately financed conversion projects. This is the highest rating extended to housing construction of any type. At present, private conversion already receives an AA-4 rating for purchases of necessary soft wood lumber, with an A-1-a rating for purchases of other critical materials.

COAL RESEARCH

Arrangements were recently completed with Battelle Memorial Institute, Columbus, Ohio, to conduct one of the largest coal research projects ever undertaken by the coal industry. Special emphasis will be directed toward the solving of war and fuel problems of the war industries, and for the expansion and extension of earlier research.

Further development of the use of pulverized coal in forge furnaces is scheduled in the new research program. The complete conversion of coal into fuel gas by chemical and physical means will be investigated.

The research program at Battelle Memorial Institute is under the direct supervision of Ralph A. Sherman, who is a member of the Society and Chairman of the Research Technical Advisory Committee on Fuels.

SUMMARY OF LOCAL CHAPTER MEETINGS

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Northern Ohio	November 17	Salvaging of Existing Refrigeration Equipment for Emergency Use.	W. L. Fleisher.	Joint meeting with local ASRE group; showing of film, Assembly Lines of Defense.	50	1.39
Montreal	November 16	Boilers and Oil Burners.	A. E. Watts.		31	0.45
Philadelphia	November 12	How We, Individually and as Members of ASHVE, can put our Training and Experience Into the War Effort.	Maj. E. M. Culligan, National Hdqrs., Selective Service System. Lt. W. C. Sheetz, Jr., U. S. Navy. Dr. Stewart Henderson Britt, Natl. Roster of Scientific and Specialized Personnel. H. P. Gant, U. S. Ordnance Dept. Mr. Roseman, U. S. Civil Service Commission. Alexander Fleisher, Deputy Regional Dir., War Manpower Commission.	General discussion.	75	0.63
St. Louis	November 12	The Development of the Airplane for Its Function in the War.	Pres. E. O. Eastwood.	Joint meeting with Engineers' Club of St. Louis. Dinner preceding meeting at Garavelli's.	142	2.45
Manitoba	November 11	Discussion of the article — Some Practical Pointers on Temperature Control, by William Goodman.	R. L. Kent.		12	0.6
	October 7	Priorities.	E. Dack, Priorities Representative Wartime Prices and Trade Board, Dominion Govt. of Canada.		14	0.7
Cincinnati	November 10	Research and Bituminous Coals.	R. A. Sherman.	Report of Society Nominating Committee by Albert Buenger; also, report on need for club building for Engineers' Club and Technical Societies, by W. H. Junker.	21	0.42
Illinois	November 9	Victory Program—Refrigerating and Air Conditioning Industry.	J. K. Knighton.	ASRE members as guests.	57	0.42
Iowa	November 9	The Fuel Oil Situation Today.	Al Richter, Phillips Petroleum Co.	Report on bulletin being issued by Iowa State College on Fuel Conservation — How to Save Fuel.	15	0.48

CHAPTER	MEETING DATE	SUBJECT	SPEAKERS	OTHER FEATURES	ATTENDANCE	ATTENDANCE RATIO*
Kansas City	November 9	Let's Analyze These Fuel Savings Suggestions.	Harry Atwater, Combustion Equipment Co.	Remarks by Eugene Lyon, Chairman of Fuel Oil Panel, Rationing Board; W. A. Russell spoke on obtaining new members; E. K. Campbell reported on Council meeting in Washington and thanked members for assistance in fuel rationing; L. T. Mart elected as Representative on Nominating Committee and M. M. Rivard as alternate.	35	0.76
Pittsburgh	November 9	Air Purification.	Henry Sleik, W. B. Conner Engineering Corp., New York, N. Y.	Illustrated with slides. Pres. C. A. Humphreys introduced W. A. Evans and J. L. McCauley of Cleveland, R. B. Fries, Fort Worth.	24	0.4
Western Michigan	November 9	Fuel Savings —symposiums of local members:				
		Steam traps and auxiliaries.	O. D. Marshall.		30	0.55
		High temperature insulation.	T. D. Stafford.			
		Domestic insulation.	J. A. Adams.			
		Weatherstripping.	Ivan Anderson.			
		Conversion from oil to coal.	M. L. Johnson.			
Southern California	November 4	Why Does It Take So Long?	Donald Stone.		37	0.29
Golden Gate	November 3	Heat Absorption Properties of Paints.	O. W. Johnson.	Discussion of OPA Order No. 251.	20	0.25
	October 14	The Place of the Engineer in the War.	Dr. B. M. Woods.		30	0.39
North Carolina	October 30	Heating, Ventilating and Air Conditioning of Modern Aircraft.	Pres. E. O. Eastwood.		99	2.1
			E. R. Harding	Greeting to visitors.		
			R. M. Rothgeb.	Pres., Raleigh Engineers' Club.		
			F. B. Turner.	Greetings from Raleigh Chapter ASME.		
			R. B. Rice.	Introduced President Eastwood.		
				Dinner served by Engineering Honorary Fraternity at State College; 20 seniors from Duke and N. C. State were guests.		
New York	October 19	Modern Hot Water Heating Practice. Mr. Blankin described the latest developments in hot water heating system design and their application for residences as well as large defense housing projects.	M. F. Blankin.	Two motion picture films: The Army Behind the Army; and Coal for Victory. H. J. Ryan elected to Board of Governors to fill vacancy caused by resignation of D. F. Parker.	60	0.22

*The attendance ratios shown represent the meeting attendance divided by the Chapter membership. These will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by other local chapters, and may be helpful in deciding on subjects for other chapter meetings.

Reprints of ASHVE Papers

There are available in the files of the Society many reprints of papers which have appeared in its Journal and Transactions. For those who wish copies they can be supplied at a nominal cost of 10 cents each for Series 4-100 to 28-818 (1904-1928) and 15 cents each for Series 28-818 to 42-1222 (1928-1942). Orders should include number and title.

Air Cleaners and Washers, Dust and Dust Removal

No.

41-1169 A Comparison of the Weight, Particle Count and Discoloration Methods of Testing Air Filters, by F. B. Rowley and R. C. Jordan

37-1060 Adaptability of Pre-Cooling Coils to Air Washer Systems, by John Everetts, Jr.

38-1094 Air Filter Performance as Affected by Kind of Dust, Rate of Dust Feed and Air Velocity Through Filter, by F. B. Rowley and R. C. Jordan

39-1122 Air Filter Performance as Affected by Low Rate of Dust Feed, Various Types of Carbon, Dust Particle Size and Density, by F. B. Rowley and R. C. Jordan

31-891 Air Pollution from the Engineer's Standpoint, by H. B. Meller

37-1070 Alternate Method of Comparing Dust Arrestance of Air Cleaning Devices, by Arthur Nutting

27-762 Design and Application of Oil Coated Air Filters, by H. C. Murphy

29-843 Determining the Quality of Dust in Air by Impingement, by F. B. Rowley and John Beal

40-1158 Dirt Patterns on Walls, by R. A. Nielsen

35-1023 The Dust Problem in Air Conditioning, by F. B. Rowley

12-274 Dust in Relation to Heating, by Konrad Meier

41-1187 Economical Air Velocities for Mechanical Air Filtration, by F. B. Rowley and R. C. Jordan

40-1145 Effect of Lint on Air Filter Performance, by F. B. Rowley and R. C. Jordan

27-761 An Improved Simple Method of Determining the Efficiency of Air Filters, by H. G. Tufty and Eugene Mathis

34-01 A Method of Testing Filters Against Pollens, Bacteria and Molds, by Philip Drinker and W. F. Wells

42-1218 Overloading of Viscous Air Filters During Accelerated Tests, by F. B. Rowley and R. C. Jordan

14-360 Preliminary Report of Committee for Standardizing a Method of Testing Air Washers, by A. E. Stacey, Jr., *Chairman*

15-370 The Problem of City Dust, by R. P. Bolton

10-216 Report of Committee on Air Washers

28-812 Study of Dust Determinators, by F. B. Rowley and John Beal

38-1091 Test Method for Air Filters, by R. S. Dill

33-960 Testing and Rating of Air Cleaning Devices Used for General Ventilation Work, by S. R. Lewis

25-714 The Use of Owens' Jet Dust Counter and of Electric Precipitation in the Determination of Dusts, Fumes, and Smokes in Air, by Philip Drinker

Air Conditioning for Comfort

35-05 Chicago Standards for Certified Air Conditioning, by S. R. Lewis

35-08 Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet

40-1152 Advantages of Bactericidal Ultra-violet Radiation in Air Conditioning Systems, by H. C. Rentschler and Rudolph Nagy

42-1219 Air Conditioning of Blackout Plants, by W. A. Grant

30-864 Air Conditioning the Halls of Congress, by L. L. Lewis and A. E. Stacey, Jr.

34-986 Air Conditioning in Its Relation to Human Welfare, by C. A. Mills, M.D.

29-837 Air Conditioning Systems of a Detroit Office Building, by H. L. Walton and L. L. Smith

38-1074 Application and Economy of Steam Jet Refrigeration to Air Conditioning, by A. R. Mumford and A. A. Markson

36-1046 Application Factors Which Govern the Selection of Refrigerating Equipment for Air Conditioning Service, by J. R. Hertzler

39-1125 Application of Summer Weather Design Data, by John Everetts, Jr.

41-1174 Comfort Requirements for Low Humidity Air Conditioning, by F. C. Houghten, H. T. Olson and S. B. Gunst

42-1196 Comfort with Summer Air Conditioning; ASHVE Technical Advisory Committee, Thomas Chester, *Chairman*

40-1166 Cooler Footcandles for Air Conditioning, by G. W. Darley

35-1002 Cooling Requirements of Single Rooms in a Modern Office Building, by F. C. Houghten, Carl Gutberlet and A. J. Wahl

36-00 Cooling Requirements for Summer Comfort Air Conditioning, by F. C Houghten, F. E. Giesecke, C. Tasker and Carl Gutberlet

38-1100 Cooling Requirements for Summer Comfort Air Conditioning in Toronto, by C. Tasker

42-1205 Determining Sound Attenuation in Air Conditioning Systems, by D. A. Wilbur and R. F. Simons

No.

40-1146 Dynamic and Thermal Behavior of Water Drops in Evaporative Cooling Processes, by H. B. Nottage and L. M. K. Boelter

38-1083 Effects of Artificial Lighting on Air Conditioning, by Walter Sturrock

39-1135 Fire Protection for Air Conditioning Systems, by R. C. Loughead

37-1061 How Much Power Will an Air Conditioning System Use? by A. M. Marston

41-47 Interpretation of Summer Weather Temperature Data for Design, by J. D. Kroeker and H. V. Soballe

40-18 Methods of Rating the Noise from Air Conditioning Equipment, by J. S. Parkinson

34-995 Operating Results of an Air Conditioning System Compared with Design Figures, by J. R. Hertzler

34-976 A Proving Home for Air Conditioning Investigations, by Elliott Harrington and L. A. Mears

28-814 Refrigeration as Applied to Air Conditioning, by R. W. Waterfill

34-979 Study of Summer Cooling in the Research Residence for the Summer of 1933, by A. P. Kratz and S. Konzo

35-1012 Study of Summer Cooling in the Research Residence for the Summer of 1934, by A. P. Kratz, S. Konzo, M. K. Fahnestock and E. L. Broderick

33-947 Study of Summer Cooling in the Research Residence at the University of Illinois, by A. P. Kratz and S. Konzo

36-1034 Study of Summer Cooling in the Research Residence Using Water from the City Water Mains, by A. P. Kratz, M. K. Fahnestock, S. Konzo and E. L. Broderick

38-1095 Study of Summer Cooling in Research Residence Using Small Capacity Mechanical Condensing Unit, by A. P. Kratz

39-1136 Summer Cooling Requirements in Washington, D. C., and Other Metropolitan Districts, by F. C. Houghten, Carl Gutberlet and A. A. Rosenberg

39-1137 Study of Summer Cooling in the Research Residence for the Summer of 1938, by A. P. Kratz, S. Konzo, M. K. Fahnestock and E. L. Broderick

37-1062 Study of Summer Cooling in the Research Residence Using Water at Temperatures of 52 F and 46 F, by A. P. Kratz, S. Konzo and E. L. Broderick

35-1003 Study of Unit Room Coolers in the Research Residence, by A. P. Kratz, M. K. Fahnestock and S. Konzo

41-1177 Summer Cooling in Research Residence with a Gas-Fired Dehydration Cooling Unit, by A. P. Kratz, S. Konzo and E. L. Broderick

42-1197 Use of Cold Accumulators in the Air Conditioning Field, by R. W. Evans and C. J. Otterholm

34-999 What Is the Cooling Load Factor in Air Conditioning, by John Everetts, Jr.

Air Ducts, Dampers, Registers and Grilles and Air Flow

40-1154 Analysis of the Factors Affecting Duct Friction, by J. B. Schmieler, F. C. Houghten and H. T. Olson

35-1014 Characteristics of Registers and Grilles, by J. H. Van Alsburg

35-1015 Classroom Odors with Reduced Outside Air Supply, by F. C. Houghten, H. H. Trimble, Carl Gutberlet and M. F. Lichtenfels

42-1204 Entrainment and Jet-Pump Action of Air Streams, by G. L. Tuve, G. B. Priester and D. K. Wright, Jr.

40-1165 Development of Instruments for the Study of Air Distribution in Rooms, by A. P. Kratz, A. E. Hershey and R. B. Engdahl

42-1216 Effect of Vanes in Reducing Pressure Loss in Elbows in 7-Inch Square Ventilating Duct, by M. C. Stuart, C. F. Warner and W. C. Roberts

13-318 Flow of Air in Ventilating Ducts, by L. A. Harding

38-1092 Flow of Air Through Exhaust Grilles, by A. M. Greene, Jr.

29-844 Instruments for the Measurement of Air Velocity, by J. H. Parkin

32-936 Investigation of Air Outlets in Class Room Ventilation, by G. L. Larson, D. W. Nelson and R. W. Kubasta

30-857 The Measurement of the Flow of Air Through Registers and Grilles, by L. E. Davies (Part I)

31-911 The Measurement of the Flow of Air Through Registers and Grilles, by L. E. Davies (Part II)

33-966 The Measurement of the Flow of Air Through Registers and Grilles, by L. E. Davies (Part III)

37-1051 Noise Characteristics of Air Supply Outlets, by D. J. Stewart and G. F. Drake

40-1155 Performance of Stack Heads, by D. W. Nelson, D. H. Krans and A. F. Tuthill

42-1206 Performance of Stack Heads Equipped with Grilles, The, by D. W. Nelson, D. H. Lamb and G. E. Smedberg

38-1082 Performance Tests of Asbestos Insulating Air Duct, by R. H. Heilman

42-1211 Pressure Loss Caused by Elbows in 8-Inch Round Ventilating Duct, by M. C. Stuart, C. F. Warner and W. C. Roberts

No.

13-316 Report of Committee on Method of Taking Anemometer Readings

38-1087 Study of Methods of Control and Types of Registers as Affecting Temperature Variations in Research Residence, by A. P. Kratz and S. Konzo

31-884 Some Studies on the Absorption of Noise in Ventilating Ducts, by G. L. Larson and R. F. Norris

39-1140 Use of Air-Velocity Meters, by G. L. Tuve, D. K. Wright, Jr., and L. J. Seigel

Automatic Heat and Humidity Control

34-970 Automatic Controls for Forced-Air Heating Systems, by S. Konzo and A. F. Hubbard

36-1027 Comparative Study of Combustion Results with Various Thermostats, by B. E. Shaw

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29-842 Errors in the Measurement of the Temperature of Flue Gases, by P. Nicholls and W. E. Rice

36-1038 Performance of an Underfeed Domestic Stoker, by T. G. Estep and D. C. Saylor

35-1001 Some Recent Studies on the Ashes in Coal, by T. G. Estep

32-928 Study of the Combustible Nature of Solid Fuels, by R. V. Frost

Sound Control

14-351 Reduction or Elimination of Noise Attending the Operation of Mechanical Ventilating Machinery, by R. W. Pryor, Jr.

Steam Heating Systems and Piping

30-872 Capacity of Dry Return Mains for Steam and Vapor Heating Systems, by F. C. Houghten and Carl Gutberlet

29-838 Capacity of Radiator Supply Branches for One- and Two-Pipe Systems, by F. C. Houghten, M. E. O'Connell and Carl Gutberlet

No.

31-889 Capacity of Return Risers for Steam and Vapor Heating Systems, by F. C. Houghten and Carl Gutberlet

15-379 Capacity of Steam Pipes at Different Pressures, by J. S. Otis

27-780 Capacity of Up-Feed Steam Heating Risers for One- and Two-Pipe Systems, by F. C. Houghten and M. E. O'Connell

7-181 The Combined Pressure and Vacuum System of Steam Heating, by G. D. Hoffman

37-1058 Condensate and Air Removal Rates in a Vacuum Heating System, by D. W. Nelson

33-954 Condensate and Air Return in Steam Heating Systems, by F. C. Houghten and J. L. Blackshaw

33-953 Flow of Condensate and Air in Steam Heating Returns, by F. C. Houghten and Carl Gutberlet

14-335 Flow of Steam in Pipes, by W. F. Verner

27-771 Pressure Differences in Steam Heating Systems and Their Bearing on Operation—a Comparative Test of Two Types of Heating Systems, by C. A. Dunham

6-157 A New Vapor System of Vacuum Heating, by J. A. Donnelly

19-527 Remodeling a Heating System, by Helen R. Innis

10-218 Report of Review Committee on Steam Heating for Residences and Small Buildings

6-156 Sizes of Return Pipes in Steam Heating Apparatus, by J. A. Donnelly

5-137 Steam Heating in Connection with Condensing Engines, by R. P. Bolton

12-279 Steam Heating Large Department Stores, by D. S. Boyden

Temperature, Humidity and Air Motion in Relation to Comfort, Health and Efficiency

40-1150 Calculation of Coil Surface Areas for Air Cooling and Dehumidification, by John McElgin and D. C. Wiley

39-1108 Cardiac Output, Peripheral Blood Flow, and Blood Volume Changes in Normal Individuals Subjected to Varying Environmental Temperatures, by F. K. Hick, R. W. Keeton, Nathaniel Glickman and H. C. Wall

40-07 Chemical Dehumidification Agents, by F. R. Bichowsky

41-1176 Comfort and Health and Temperature—A Mathematical Solution, by W. L. Fleisher and W. L. Fleisher, Jr.

27-770 The Comfort Zone for Men at Rest and Stripped to the Waist, by C. P. Yaglou

38-1093 Condensation Nuclei Content of Air as Related to Air Freshness, by R. A. Nielsen

34-992 Dry Bulb *vs.* Effective Temperature Control, by A. E. Beals

37-1053 Fever Therapy Induced by Conditioned Air, by F. C. Houghten, M. B. Ferderber and Carl Gutberlet

40-1161 Fever Therapy Locally Induced by Conditioned Air, by M. B. Ferderber, F. C. Houghten and Carl Gutberlet

38-1103 General Reactions of 274 Office Workers to Summer Cooling and Air Conditioning, by F. C. Houghten

31-908 Heat and Moisture Losses from Men at Work and Application to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. E. Miller and W. P. Yant

32-993 How to Use the Effective Temperature Index and Comfort Charts, by C. P. Yaglou

12-295 Humidity in Relation to Heating and Ventilation, by L. C. Soule

33-959 Indices of Air Change and Air Distribution, by F. C. Houghten and J. L. Blackshaw

36-03 Independent Dehumidification, by L. S. Ourusoff

41-1175 The Influence of Physiological Research on Comfort Requirements, by R. W. Keeton, F. K. Hick, Nathaniel Glickman and M. M. Montgomery

37-1054 Investigations on Exchange of Energy Between Body and Its Environment, by Charles Sheard, M. M. D. Williams and B. T. Horton

41-1188 Local Cooling of Workers in Hot Industry, by F. C. Houghten, M. B. Ferderber and Carl Gutberlet

34-982 Observations of Hay-Fever Sufferers in Air Conditioned Room and the Relationship Between the Pollen Content of Out-Door Air and Weather Conditions, by T. A. Kendall and Garland Weidner

37-1066 Performance of Fin Tube Units for Air Cooling and Dehumidifying, by G. L. Tuve and C. A. McKeeman

38-1099 Performance of Surface-Coil Dehumidifiers for Comfort Air Conditioning, by G. L. Tuve

40-1151 The Peripheral Type of Circulatory Failure in Experimental Heat Exhaustion—the Role of Posture, by R. W. Keeton, F. K. Hick, Nathaniel Glickman and M. M. Montgomery

42-1208 Physiological Fatigue from Exposure to Hot Environments, by M. B. Ferderber, C. F. Houghten and W. L. Fleisher

38-1081 Physiological Reactions and Sensations of Pleasantness Under Varying Atmospheric Conditions, by C.-E. A. Winslow

27-769 Practical Application of Temperature Humidity and Air Motion Data to Air Conditioning Problems, by F. C. Houghten, W. W. Teague and W. E. Miller

41-1172 Radiation as a Factor in the Sensation of Warmth, by F. C. Houghten, S. B. Gunst and J. Suciu, Jr.

No.

40-1160 Reactions of 745 Clerks to Summer Air Conditioning, by W. J. McConnell and M. Spiegelman

39-1127 Reactions of Office Workers to Air Conditioning in South Texas, by A. J. Rummel, F. E. Giesecke, W. H. Badgett and A. T. Moses

15-01 Results of Physiological and Psychological Observations During the First Year's Experiments, by D. D. Kimball

39-1109 The Role of the Extremities in the Dissipation of Heat from the Body in Various Atmospheric and Physiological Conditions, by Charles Sheard, M. M. D. Williams, Grace M. Roth and B. T. Horton

38-1101 Seasonal Variations in Effective Temperature Requirements, by F. E. Giesecke

40-35 Seasonal Variation in Reactions to Hot Atmosphere, by F. C. Houghten, A. A. Rosenberg and M. B. Ferderber

38-1102 Shock Experiences of 275 Workers After Entering and Leaving Cooled and Air Conditioned Offices, by A. B. Newton

39-1110 Skin Temperatures of the Extremities and Effective Temperature, by Charles Sheard, M. M. D. Williams and B. T. Horton

36-1030 Subjective Reactions of Human Beings to Certain Outdoor Atmospheric Conditions, by C.-E. A. Winslow

29-831 The Summer Comfort Zone: Climate and Clothing, by C. P. Yaglou

40-1169 Study of Changes in Temperature and Water Vapor Content of Respired Air in the Nasal Cavity, by L. E. Seeley

17-454 The Testing of Atmospheric Conditions and Heating and Ventilating Equipment, by D. D. Kimball, J. I. Lyle and A. K. Ohmes

Theaters, Auditoriums, Office Buildings

38-1084 Comparative Analysis of Office Building Air Conditioning Systems, by J. R. Hertzler

9-206 A Combination Ventilating, Heating and Cooling Plant in a Bank Building, by A. M. Feldman

37-1069 Heating Requirements of an Office Building as Influenced by Stack Effect, by F. C. Houghten and Carl Gutberlet

5-152 Heating and Ventilating the Main Auditorium of the Broadway Tabernacle, New York, by C. Teran

10-228 Heating and Ventilation of Federal Buildings, by N. S. Thompson

27-776 How Design and Operation of Heating Plant Compare in an Insulated Office Building, by F. M. Holbrook

16-395 Report of Committee on Operating Costs of Public Buildings

13-312 Report of Committee on Proposed Standards for Ventilation Legislation for Motion Picture Show Places

28-803 Saving Heat in Skyscrapers, by F. C. Houghten and M. E. O'Connell

15-374 A Study of Heating and Ventilating Conditions in a Large Office Building, by C.-E. A. Winslow and G. F. Maglott

11-237 Ventilation of the Capitol, Washington, D. C., by N. S. Thompson

Unit Heating and Ventilating

42-1202 Design and Performance of a Direct-Fired Unit Heater, by R. M. Rush and H. A. Pietsch

29-841 Heat and Air Volume Output of Unit Heaters, by L. S. O'Bannon

30-856 Suggested Method of Testing Unit Heaters Suitable for Field Use, by L. S. O'Bannon

Ventilating Standards

35-1017 Air Supply to Classrooms in Relation to Vent Flue Openings, by F. C. Houghten, Carl Gutberlet and M. F. Lichtenfels

12-276 Chemical Notes on Ventilation, by P. N. Evans

16-411 An Outline of the Activities of the New York State Commission on Ventilation for the Year 1915, by G. T. Palmer

31-883 Noise and Ventilation, by G. T. Stanton

31-882 Noise Reduction in Ventilating Units, by Warren Ewald

26-743 Objectives and Standards of Ventilation, by C.-E. A. Winslow

12-300 Open Windows with Mechanical Ventilation, by R. C. Taggart

26-756 A Rational Basis for Ventilation, by J. E. Rush

39-1107 Recent Advances in Physiological Knowledge and Their Bearing on Ventilation Practice, by C.-E. A. Winslow

14-358 Report of Special Committee on Blower Systems for Heating and Ventilating, by A. M. Feldman

12-313 Report of the Committee on Legislation for Compulsory Ventilation

14-331 Report of Work of Ventilation Division of Chicago Health Department, by E. V. Hill

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42-1210 Sanitary Ventilation, by W. F. Wells

11-235 The Value of Good Ventilation, by Severance Burrage

13-329 Ventilation Division, Chicago Board of Health, by E. V. Hill

12-277 Ventilation Problems, by D. D. Kimball; The Hygiene of Ventilation, Discussion by Invited Guests of the Society

36-1031 Ventilation Requirements, by C. P. Yaglou, E. C. Riley and D. I. Coggins

37-1068 Ventilation Requirements (Part II), by C. P. Yaglou and W. N. Witheridge

Ventilating Systems

14-347 Car Ventilation, by D. I. Cooke

22-628 Comparative Tests of Automatic Ventilators, by J. P. Calderwood, A. J. Mack and C. J. Bradley

28-794 Dairy Stable Ventilation, by F. L. Fairbanks

31-881 Development of the Ventilation System of the Holland Tunnel, by A. C. Davis

28-02 School Room Ventilation, by A. C. Willard

11-248 Street-Car Ventilation, by W. Thorn

27-781 Ten Fundamentals of Unit Ventilation and Their Application, by A. J. Nesbitt

6-154 Ventilation of the Debating Rooms of the New Riksdages Building in Stockholm, by Wilhelm Dahlgren

15-375 The Ventilation of Sleeping Cars—Comparative Tests of Various Types of Exhaust Ventilators, by T. R. Crowder

12-281 Ventilation of a Steam Laundry, by A. M. Feldman

14-352 Ventilation of Telephone Booths, Including Other Applications of Small Unit Sets, by R. L. Douglass

Miscellaneous

41-1170 Comfort in High Altitude Flying, by D. W. Tomlinson

41-1183 Concerning Conservation of Underground Water with Suggestions for Control, by N. F. Porter

39-1138 Cooling Tower Performance Studies, by L. M. K. Boelter

34-972 Design and Equipment of the Pierce Laboratory, by C.-E. A. Winslow, Leonard Greenburg, L. P. Herrington and H. G. Ullman

26-752 Development of the Art of Heating and Ventilating in Canada, by L. M. Arkley

30-01 Developments of 1930 in Heating and Ventilating, by S. R. Lewis

4-131 The Education of Heating and Ventilating Engineers, by J. D. Hoffman

15-364 Engine Condensation, by Perry West

13-323 Expense of Operating Heating and Ventilating Plants, by H. M. Hart

14-354 Heating Industry in Canada, by N. A. Hill

12-285 Heating a Swimming Pool, by C. Teran

7-178 Heating and Ventilating of Cars, by E. R. Swan

12-290 Heating in Turkey, by J. R. Allen

15-365 The Heating Value of Exhaust Steam, by D. M. Myers

25-712 Heating and Ventilation of a Modern Steam Power Station, by D. S. Boyden and A. B. Williams

28-818 Heating and Ventilating Problems of Gas Cell Manufacture for Air Ships, by D. E. Humphrey

14-355 Hydro-Electric Power Compared with Steam, by R. P. Bolton

41-1186 The Interaction Constant for Moist Air, by J. A. Goff and A. C. Bates

4-123 The Metric System, by C. F. Hauss

6-164 Notes on the Use of Feed Water Heaters in Connection with Heating Systems, by W. G. Snow

41-1189 Performance Characteristics of a Forced Draft Counterflow Spray Cooling Tower, by H. H. Niederman, E. D. Howe, J. P. Longwell, R. A. Seban and L. M. K. Boelter

30-849 Power from Process and Space Heating Steam, by L. A. Harding

36-1041 Progress in Air Conditioning in the Last Quarter Century, by W. H. Carrier

31-07 Progress in Heating and Ventilating During the Past Quarter of a Century, by R. P. Bolton

41-49 Recent Developments in Absorption Refrigeration, by Glen Miller

41-1179 Reheating by Means of Refrigerant Compressor Discharge Gas, by S. F. Nicoll

7-169 The Relation of the Force of Gravity to Some of the Economics of Heating, by J. M. W. Kitchen

4-212 A Review of Some Heating Literature, by H. J. Barron

35-1007 Sun Effect and the Design of Solar Heaters, by H. L. Alt

35-1008 The Thermo-Integrator—A New Instrument for the Observation of Thermal Interchanges, by C.-E. A. Winslow and Leonard Greenburg

5-149 Sheet Metal Radiation, by H. W. Nowell

12-292 The Time Element in Heating Apparatus, by J. A. Donnelly

13-322 Time Analysis in Starting Heating Apparatus, by R. C. Taggart

42-1207 Vapor Pressure of Ice from 32 to —280 F, by J. A. Goff

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 28 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by January 15, 1943, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ARVIDSON, ERNEST R., Electrical Draftsman, Carbide & Carbon Chemicals Corp., South Charleston, W. Va.	J. M. Musser L. J. DuBois	E. F. Weber E. E. Carlson
BARNES, LEWIS L., Chief Engr., Carrier—Atlanta Corp., Atlanta, Ga.	C. L. Templin L. F. Lawrence, Jr.	I. B. Kagey R. F. Hahn
BASHAK, CIHAT M., Student, University of Michigan, Ann Arbor, Mich.	Axel Marin C. F. Kessler	F. N. Calhoon *R. S. Hawley
BENTSON, ROBERT J., Engr., General Electric Co., West Lynn, Mass.	E. G. Carrier J. W. Brinton	J. R. Bergan W. G. Jennings
BLAKE, JOHN L., Chief Engr. (Air Cond. Dept.), M.G.M. Studios, Culver City, Calif.	J. F. Park R. S. Farr	H. B. Lauer A. J. Hess
BORNQUIST, GEORGE W., Pres., Bornquist, Inc., Chicago, Ill.	M. F. Mattingly R. E. Moore	C. E. Pullum W. B. Graves
BRICKHAM, NELSON H., Assoc. Mech. Engr., Post Engineers, Fort Warren, Wyo.	F. L. Adams L. R. O'Rear	O. S. Ward J. J. Philippi
CALLAN, JOHN J., Jr., Mgr. Htg. Equip. Dept., Claflin-Sumner Co., Worcester, Mass.	D. J. Edwards E. G. Carrier	D. W. Blair H. M. Tarr
COCKLEY, JONATHAN E., Jr., Electrical Engr., Public Service Co. of Indiana, Inc., Greencastle, Ind.	W. D. Redrup G. A. Voorhees	L. W. Clark *J. A. Bamberger
DAHL, LAWRENCE J., Student, University of Minnesota, Minneapolis, Minn.	R. C. Jordan F. B. Rowley	C. E. Lund H. M. Betts
DONELSON, WILLIAM N., Engr., Modine Mfg. Co., Racine, Wis. (*Advancement*).	A. G. Dixon H. A. Pillen	Benjamin Spieth W. R. Stevens
EPSTEIN, LEON S., Asst. Engr., U. S. Navy (Bureau of Ships; Air Cond. Section), Washington, D. C.	T. H. Urdahl E. R. Queer	J. H. Van Alsburg A. S. Gates, Jr.
EYNON, WALTER E., Pres. & Treas., A. C. Eynon Plumbing Co., Inc., Canton, Ohio.	A. L. Vanderhoof D. L. Taze	W. M. Rowe R. T. Southmayd
GLANCE, ALVIN C., Field Engr., Anthracite Industries, Inc., New York, N. Y.	A. H. Schroth H. J. Kirkendall	A. A. Marks J. L. Lehman
JARVIS, GEORGE E., Vice Pres. & Sec'y, A. E. Holmes & Bro. Co., Superior, Wis. (*Reinstatement*)	F. F. Lange Charles Foster	E. H. Seelert R. C. Colman
KASAMEYER, ALFRED L., Engr., Detroit Edison Co., Detroit, Mich.	G. D. Winans J. H. Walker	G. H. Tuttle J. N. Livermore
LECUREUX, EZRA E., Chief Mech. Inspector, Federal Defense Housing Agency, Sylacauga, Ala.	Haydn Myer *A. D. Powers	*A. R. Frahn *H. A. Boisclair
MARSALIS, MARTIN E., Owner, American Metal Products Co., Fort Worth, Tex.	R. K. Werner H. W. Skinner	E. T. Gessell J. A. Roy
MARTIN, WILLIAM J., Pres. & Chief Engr., Economy Electric Manufacturing Co., Inc., Cicero, Ill.	C. E. Owen W. J. MaGirl	E. C. Kuntz C. H. Burnap
MCCALLUM, ALLAN W., Mgr., Anthes Foundry, Ltd., Winnipeg, Man., Canada.	E. J. Argue P. L. Charles	J. B. Steele William Glass
NOLAN, JOHN J., Owner, J. J. Nolan & Co., Memphis, Tenn.	R. H. Hoshall R. L. Spitzley	C. M. Baumgartner C. E. McCoy
PRIESTER, GAYLE B., Instructor Mech. Engrg., Case School of Applied Science, Cleveland, Ohio. (*Advancement*)	C. A. McKeeman G. L. Tuve	F. H. Rose D. K. Wright, Jr.
RUCHTE, CARL O., State Fuel Rationing Officer, O.P.A., Lincoln, Neb.	H. W. Stanton C. E. Wiser	D. D. Williams G. E. Merwin
SCHOEN, DANIEL D., Mech. Engr., Brooklyn Navy Yard, Brooklyn, N. Y.	*R. G. Dewdney Theodore Raynis	*J. I. Cohen *Gerard Suda
SCOTT, DONALD C., Mech. Engrg. Consultant, Ludlow, Manufacturing & Sales Co., Wilbraham, Mass.	*E. O. Knight *David Kinghorn, Jr.	*C. F. Bradley *E. J. Ambrose
THAYER, HARDING H., Htg. Engr., Blaw-Knox Div., Blaw-Knox Co., Pittsburgh, Pa.	Roy Brauer G. M. Comstock	F. C. McIntosh R. B. Stanger
TILLOTSON, JOHN J., Mgr. Air Cond. Engrg. and Service, Danforth Co., Pittsburgh, Pa.	C. M. Humphreys E. C. Smyers	T. F. Rockwell R. H. Sweeney
WILLIAMS, WILLIAM A., Engr., General Electric Co., West Lynn, Mass.	E. G. Carrier J. W. Brinton	J. R. Bergan W. G. Jennings

*Non-member.

Candidates Elected

In the past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

GIFFORD, EDMUND W., Mgr., Himelblau, Byfield & Co., Milwaukee, Wis. (*Reinstatement*).

PENN, LESTER W., Chief Engr., W. J. Knight & Co., St. Louis, Mo.

ASSOCIATES

LAVELLE, ANTHONY E., Htg. Contractor, The Gorman-Lavelle Plumbing & Heating Co., Cleveland, O.

JUNIORS

KAYSER, PHILLIP G., Jr., Mech. Engr., McQuay, Inc., Minneapolis, Minn.

MARKSON, WESLEY H., Jr., Engr., McQuay, Inc., Minneapolis, Minn.

MURPHY, EUGENE F., Instructor, University of California, Berkeley, Calif.

RICHARDSON, WALTER A., Engr., Thorn & Hoddle, Ltd., London, England.

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AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

51 Madison Ave., New York, N. Y.

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Two Years: A. P. KRATZ, W. A. RUSSELL, L. P. SAUNDERS, C. TASKER.

One Year: J. F. COLLINS, JR., W. L. FLEISHER, E. N. MCDONNELL, T. H. URDAHL, C.-E. A. WINSLOW, F. C. MCINTOSH, *Ex-Officio.*

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Standards—S. H. Downs, *Chairman*, L. G. Miller, C. Tasker.

Meetings—A. P. Kratz, *Chairman*, L. P. Saunders, T. H. Urdahl.

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Admission and Advancement—Earle W. Gray, *Chairman* (*one year*), E. P. Heckel (*two years*), T. T. Tucker (*three years*).

ASHVE-ASTM-ASRE-NRC Committee on Thermal Conductivity: F. C. Houghten, *Chairman;* C. B. Bradley, H. C. Dickinson, R. H. Heilman, E. R. Queer, F. B. Rowley, T. S. Taylor and G. B. Wilkes.

ASHVE-IES Joint Committee on Lighting and Air Conditioning—H. M. Sharp, *Chairman;* W. R. Beach, B. C. Candee, W. G. Darley, C. L. Kribs, Jr., P. M. Rutherford, Jr.

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Constitution and By-Laws—Albert Buenger, *Chairman;* L. T. Avery, R. H. Carpenter.

Committee on Code for Testing Surface Coils for Heating and Cooling—C. A. McKeeman, *Chairman;* Tom Brown, E. L. Hogan, H. F. Hutzel, L. E. Moody, A. F. Nass, S. F. Nicoll, M. Noble, L. P. Saunders, and D. C. Wiley.

Committee on Safety Regulations for Heating, Ventilating and Air Conditioning Systems—N. A. Hollister, *Chairman;* F. H. Buzzard, B. F. McLouth, G. P. Nachman, and C. H. Randolph.

Committee on ASHVE Code for Testing Air Cleaning Devices—John Howatt, *Chairman;* O. W. Armspach, J. L. Blackshaw, R. S. Dill, S. P. Eagleton, S. R. Lewis, Arthur Nutting, G. W. Penney, F. B. Rowley, J. H. Waggoner, and Dr. Leonard Greenburg, *Ex-Officio*

Guide Publication—A. J. Offner, *Chairman;* P. D. Close, S. Konzo, C. S. Leopold, G. L. Tuve.

F. Paul Anderson Award—M. F. Blankin, *Chairman;* W. H. Carrier, J. D. Kroeker, J. F. McIntire, F. B. Rowley.

Joint Committee on Standards for Residence Heating—L. E. Seeley, *Chairman;* R. S. Dill, S. H. Downs, H. L. Dryden, J. G. Eadie, H. C. Meyer, Jr., R. K. Thulman, T. H. Urdahl, and H. Vermilyea.

Joint Committee to Study Uniform Methods of Heat Loss Calculation—P. D. Close, *Chairman;* A. P. Kratz, J. P. Magos, G. P. Nachman, A. F. Nass.

Joint Committee on Weather Statistics—J. F. Collins, Jr., NDHA, *Chairman:* F. H Dewey, OBI; C. M. Humphreys, ASHVE; S. Konzo, NWAHACA; Raymond Little, AGA; Dr. E. Dillen Smith, U. S. Weather Bureau.

Publication—James Holt, *Chairman* (*one year*); C. H. B. Hotchkiss (*two years*); J. H. Walker (*three years*).

War Service Committee—B. M. Woods, *Chairman;* W. A. Danielson, W. L. Fleisher, E. Holt Gurney, Thornton Lewis, A. C. Willard.

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Iowa	Perry LaRue	F. E. Triggs
Kansas City	M. M. Rivard	W. A. Russell
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Michigan	J. S. Kilner	M. B. Shea
Minnesota	R. E. Backstrom	N. D. Adams
Montreal	A. M. Peart	E. W. Twizell
Nebraska	Henry Kleinkauf	W. R. White
New York	Joseph Wheeler, Jr.	H. H. Bond
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Northern Ohio	C. A. McKeeman	C. M. H. Kaercher
Oklahoma	J. H. Carnahan	E. F. Dawson
Ontario	D. O. Price	H. R. Roth
Oregon	E. E. Carroll	B. W. Farnes
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